Cloud Computing and Internet of Things (IoTs)

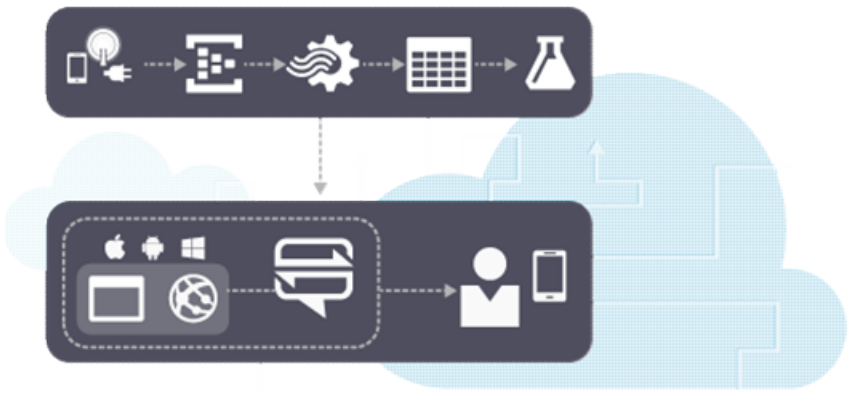
Topics

- What is IoT?
- Basic concepts of IoT
- Infrastructure of IoT
- IoT Application
- IoT in Azure Cloud
- IoT Hub
- Connecting IoT Devices to Azure
- Event Data Collection
- Azure Stream Analytics
- Azure Notification Hub

What is IoT?

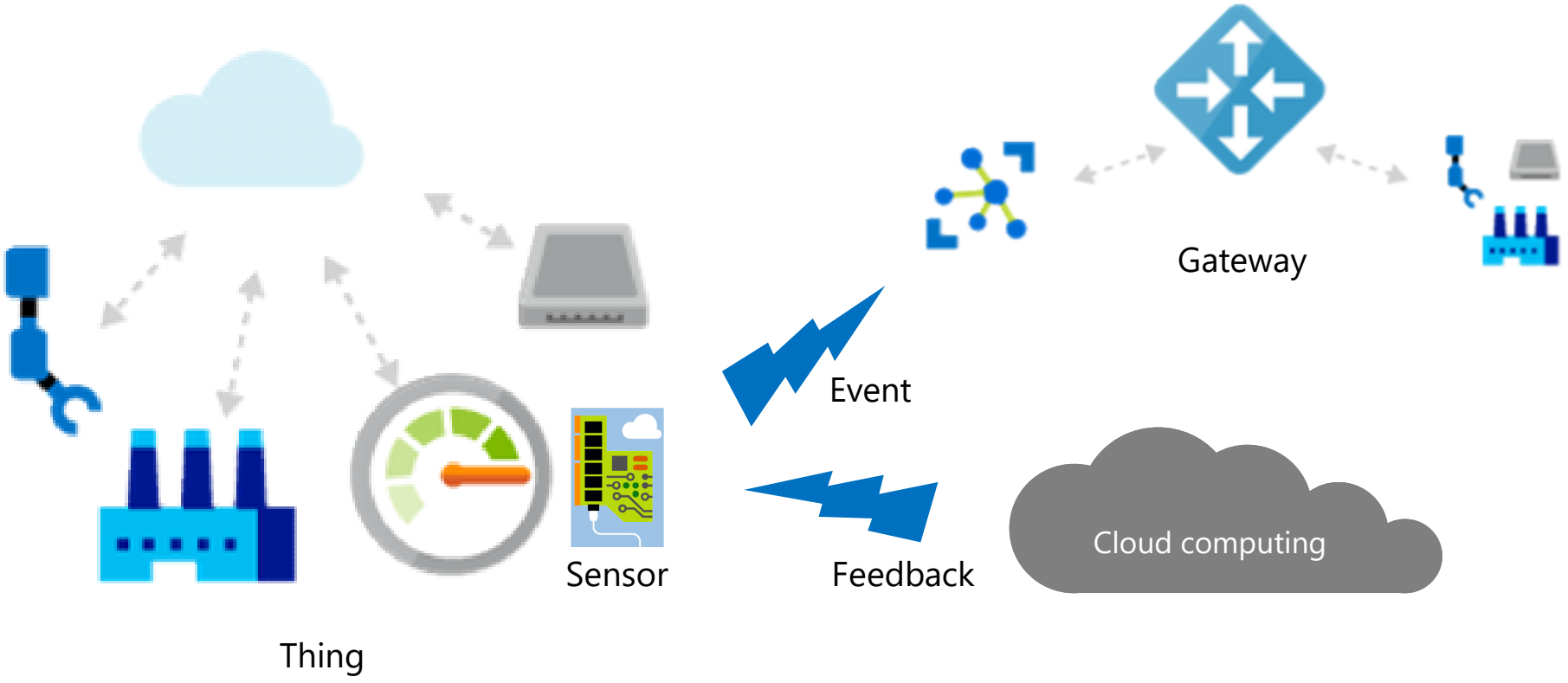
Intelligent interactivity between human and things to exchange information & knowledge

A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things[1].



1. http://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx

What is IoT? (Cont.)

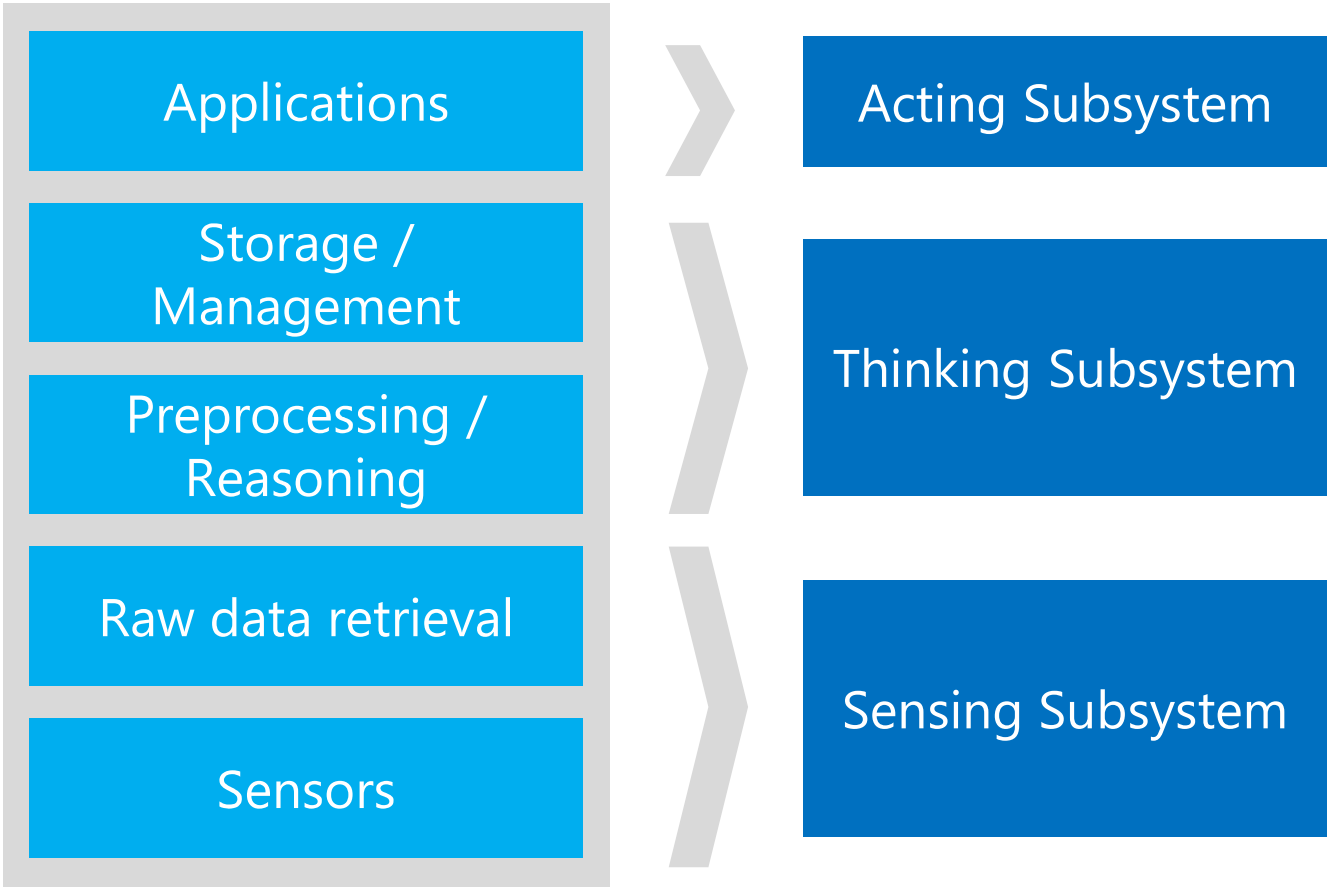


What is IoT? (Cont.)

Keywords and Concept of Internet of Things

Concept	Description
Things	Sense, Compute, Communicate and Act
Network (Infrastructure)	Web of things, Internet of Everything, Cloud Networks
Data	Collect, analyze and act upon

Abstract Layer of IoT



Sensor layer

3 different approaches to acquire contextual information

- Direct sensor access
- Middleware infrastructure
- Context server

Raw Data Retrieval

Responsible for the retrieval of raw context data

- Makes use of appropriate drivers for physical sensor and APIs for virtual and logical sensors.
- The query functionality is often implemented in reusable software components.

Preprocessing & Reasoning

Responsible for reasoning and interpreting contextual information

- The sensors queried in the underlying layer most often return technical data that are not appropriate to use by application.
- This layer raises the results of layer two to a higher abstraction level. The transformations include extraction and quantization operations

Storage and Management

Organizes the gathered data and offers them to the client via a public interface

- Clients may gain access in two ways:
  - Synchronous mode
  - Asynchronous mode

Application Layer

The client is realized in this layer.

- The actual reaction on different events and context-instances is implemented in this layer
- Sometimes information retrieval and application specific context management and reasoning is encapsulated in form of agents

Sensor

Sensors come in all kinds of flavors and can be combined

- A Large variety of sensors :
  - Light, acceleration, location, temperature, biological signals, infrared, so on
- Combination of multiple sensors

Sensor Types

- Physical Sensors
- Virtual Sensors
- Logical Sensors
- Sensor fusion

Sensor fusion

Techniques – detection, classification, identification of objects

- Taking observation from a number of sensors
- Solving equations to find values for variable
- Mathematical equations relate sensor observations with known quantities and variables to be discovered

Classification of Sensors

Type of context	Use Sensors
Light	Photodiodes, color sensors, IR and UV-sensors etc.
Audio	Microphones
Motion, Acceleration	Mercury switches, angular sensor, accelerometers, motion detectors, magnetic fields
Location	GPS, Global system for mobile communications, Active badge system, etc
Physical attributes	Biosensors to measure skin resistance, blood pressure

Sensing (Context Acquisition)

Context Attributes

Attribute	Description
Location	an entity's position
Identify	unique identifier
Activity	status
Time	timestamp

Sensing (RFID)

RFID (Radio Frequency Identification) tags or smart labels

- Can be read from or written to, using RFID reader with energy from a radio frequency field.
  - RFID Tag
  - RFID Reader

Sensing (Location)

Location is widely used type of context in application.

Location Sensing	Description
GPS (global positioning system)	Use satellites, several meters accuracy
Mobile Phone Network	Suburb or town, 150~300 meter accuracy
WLAN	Triangulation with multiple access points, 1~2 meter accuracy
Bluetooth	short-range networking
Ubisense Sensor	for a tagged person, 15 cm accuracy

Sensor usage

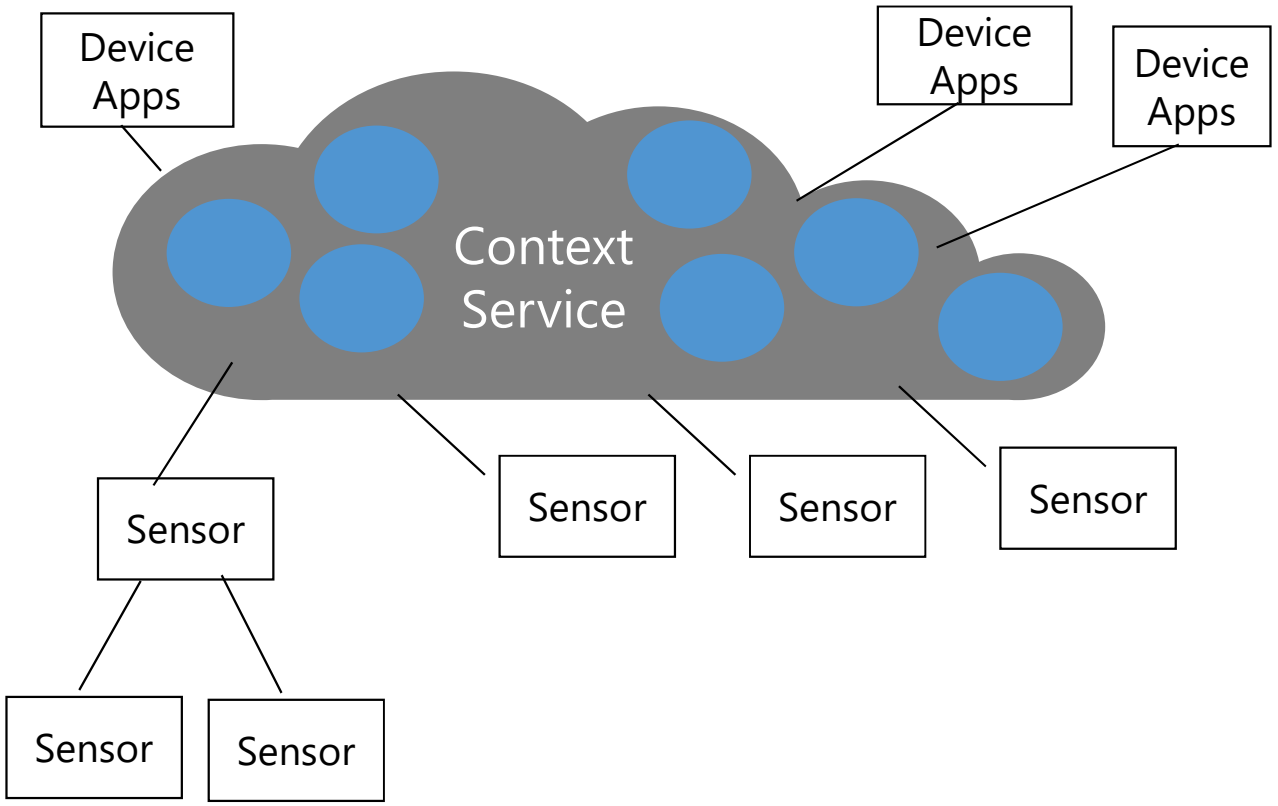
Where to put sensor

- Depends on the application and the type of sensor
- Embedded in the environment as part of the room, car, or worn on people
- Used to detect activities within an environment

Infrastructure for IoT

- Infrastructure
  - A well established, pervasive, reliable, and publicly accessible set of technologies that acts as a foundation for other systems.
- A Middleware layer
  - Between sensors on one side and devices and applications on the other

Infrastructure for IoT (Cont.)



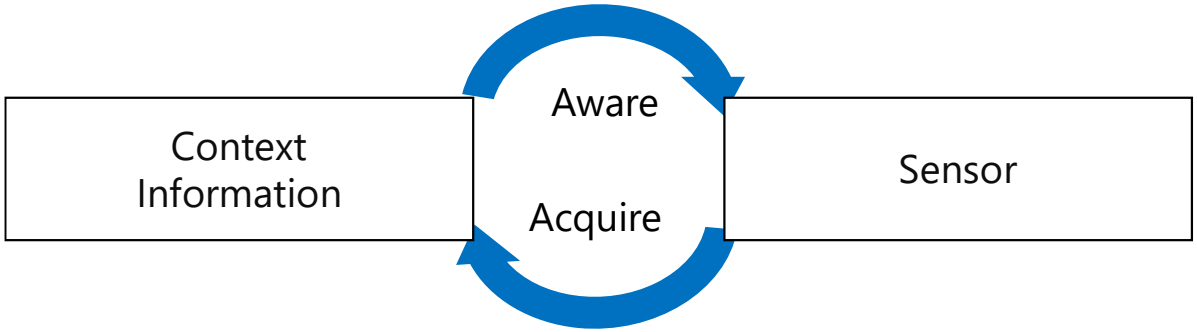
What makes IoT possible

- Integrated circuits technologies
  - Miniature
  - High computing power
  - Low power
- Wireless Technologies
  - Reaching everywhere
  - Low power
- Networks
  - Ubiquitous and Omnipresent

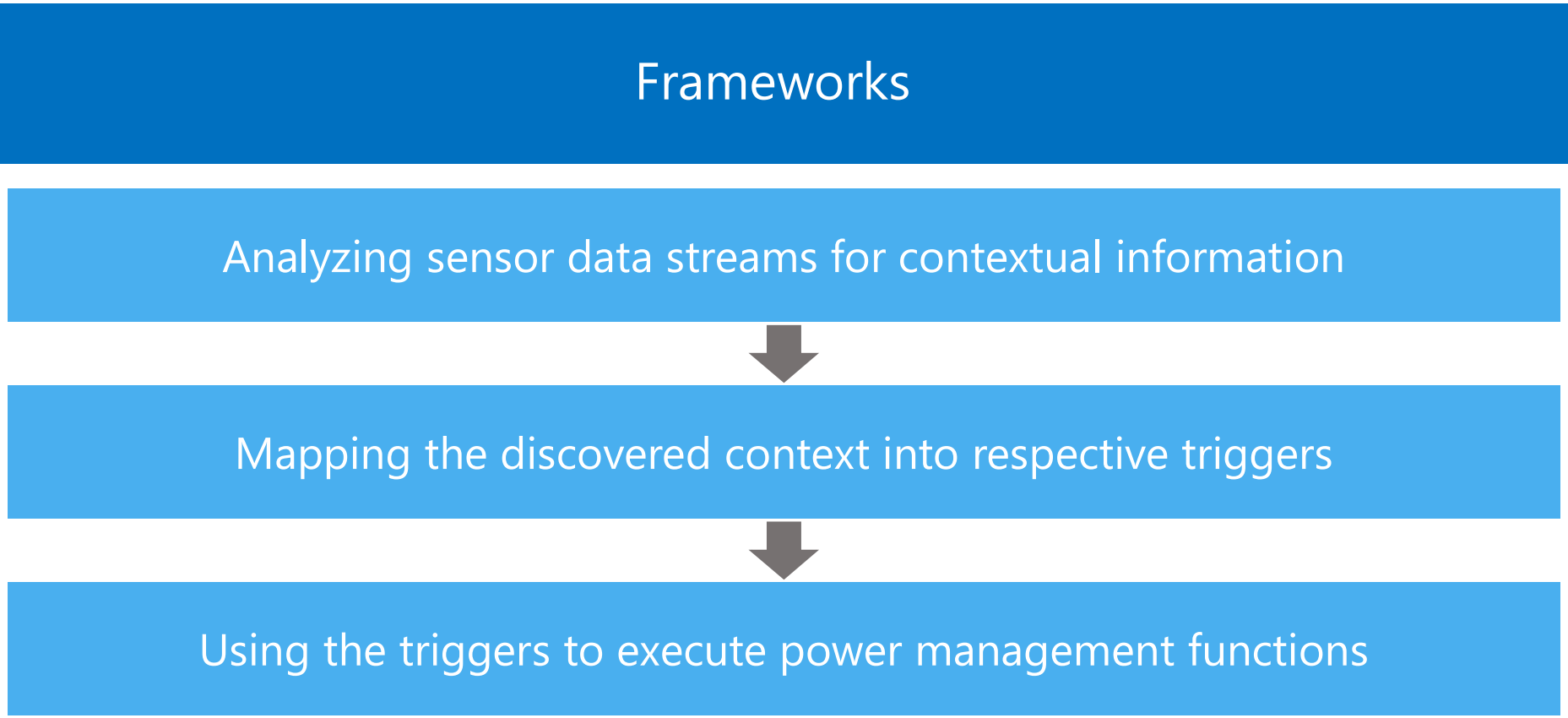
IoT in Azure Cloud

Context-Aware Sensors

- Sensors are used to acquire context information
- Sensors can be made to be aware of their own context



Context-Aware Sensor frameworks



WSN : Wireless Sensor Network

WSN : Wireless Sensor Network

- Consisting of sensing, processing, and communicating components, networked through wireless links between nodes
- Large number of sensor nodes are deployed over an area
- Mesh network: relay sensed information to base station

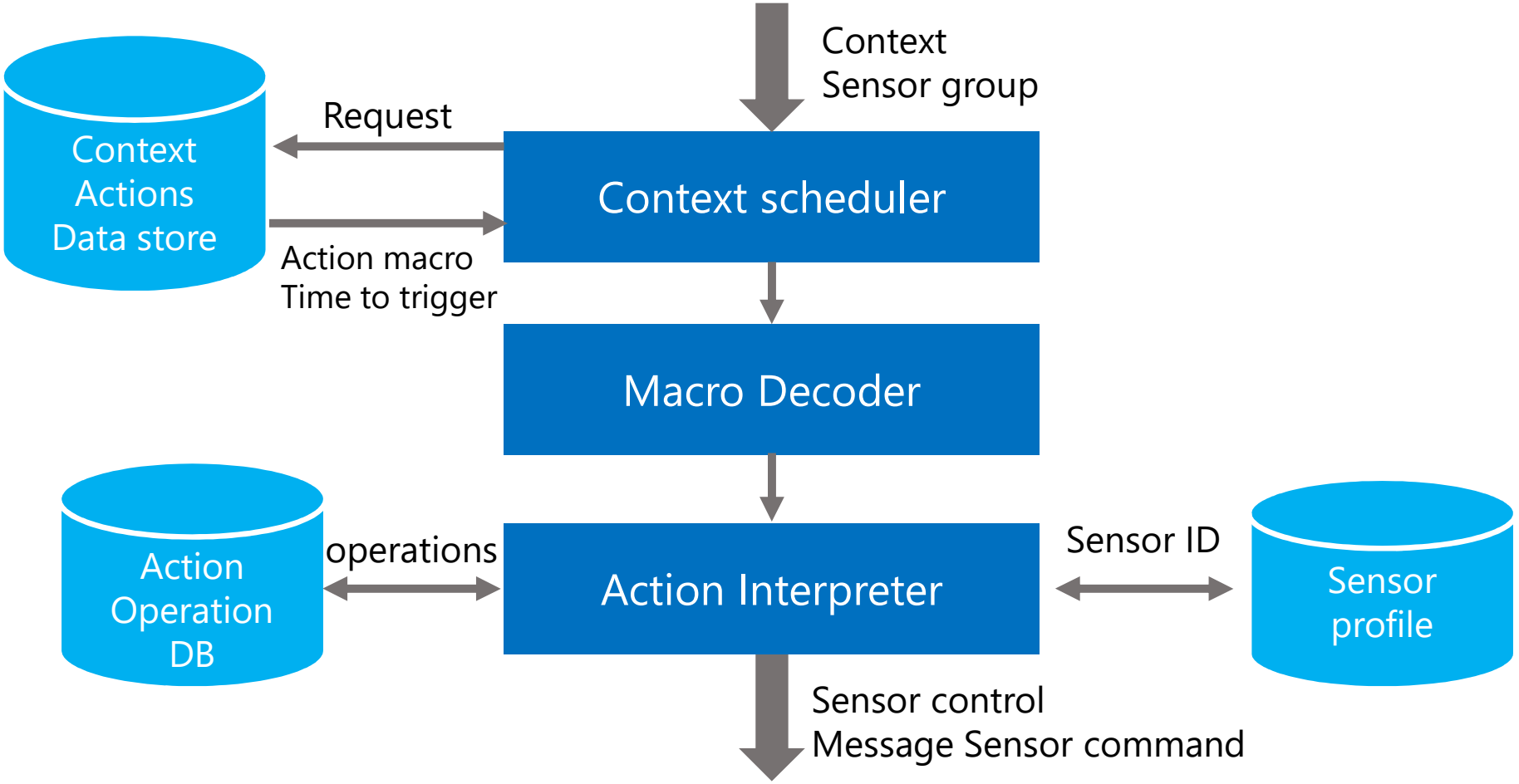
Key Component of Frameworks

- Sensor groups
- Communication server
- Context locator service

Key Component of Frameworks (Cont.)

- Context mining service
- Context trigger engine
- Context action data store

Key Component of Frameworks (Cont.)



Security

Traditional Security models

- Confidentiality
- Integrity
- Availability

Security Policy

Traditional Security is based on the concept of roles and tasks affected to these roles

- Specifies security responsibilities
- Assets or protects – Hardware, Software, Data, Networks
- Mechanisms – Cryptography, Access control, Authentication & identification, Trust management

Context-Aware Security

Context based security supports the reconfiguration of the security infrastructure according to the situation of use.

- Finer-grained security
- Adaptable security levels
- Increased traceability

Influences on Security models

- Finer-grained security
  - Grouped context for the purpose of security decisions
  - Context can be used to enhance existing security measures
- Adaptable security levels
  - Context Awareness : flexible security models can be achieved
  - Use of context : partial information access or full discourse based on situations

Influences on Security models (Cont.)

Increased Traceability

- Without the full credentials, provide the permission, with the context of location, time and witness of the event record
- Contexts improve traceability and enrich auditing, which can be traded for changes in required credentials or security levels

Context-Aware Security Policy

Formalisms for expressing context-aware security policies

- Contextual graphs
- Role-based XML languages

Security Issues

Other related issues:

- Privacy issue
  - use of context not so much for securing information as for securing context information
  - ex) protecting people's location & tracking
- Use of context in security infrastructures
  - False context can compromise security
  - Protecting the sensing and context gathering subsystems will be important → false information is not acquired
- Security in Pervasive computing

Applications of IoT

Applications of Networks and Sensors

- Warehouse Inventory management
- Smart Automotive
- Smart Building control
- Environmental monitoring
- Military battlefield intelligence/security/Surveillance
- Infrastructure protection

Requirements of IoT Application

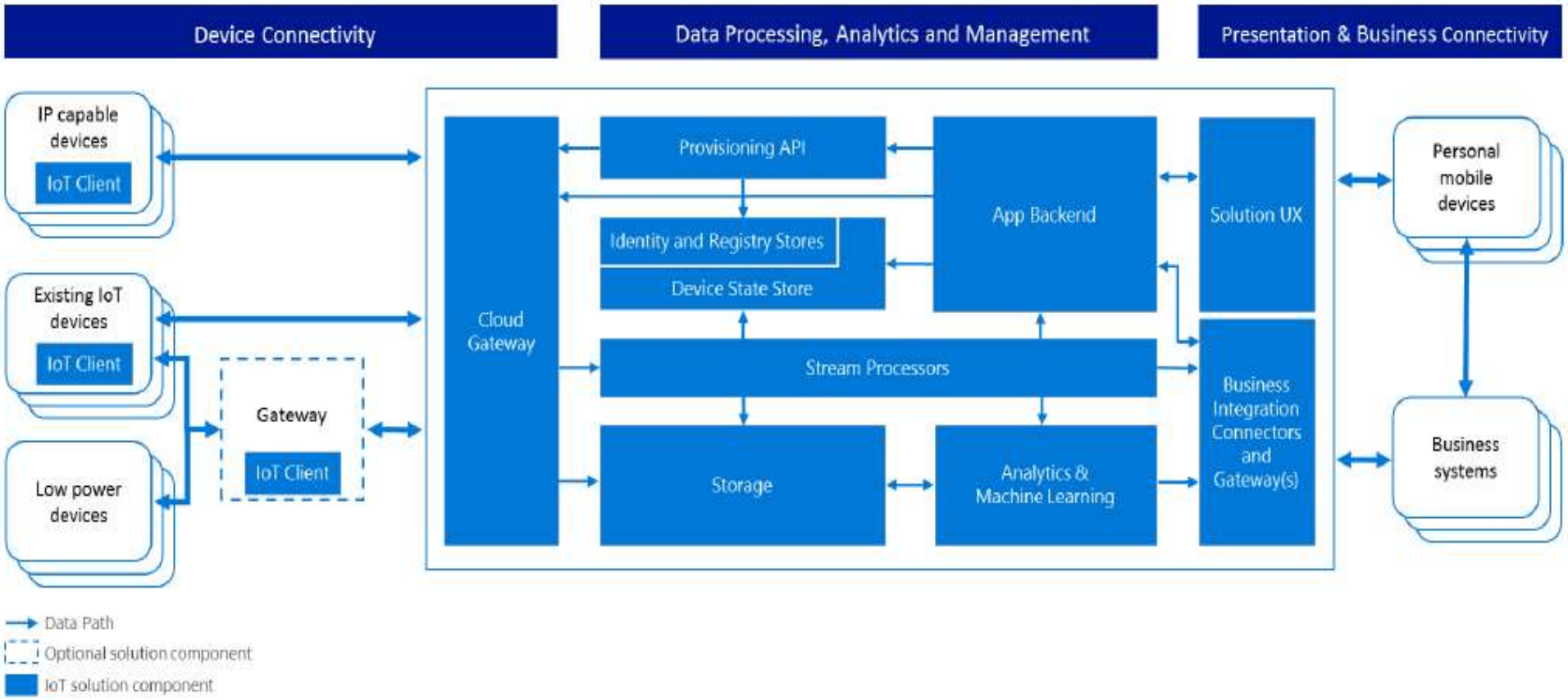
Requirements	Health	Aviation	Home Automation	Smart Cars	Industrial Control
Latency	Long	Low	Long	Low	Low
Mobility	Pedestrian	High	No	High	Low
Security	High	High	High	High	High
Protocol message size	Short	Mix	Short	Mix	Mix
Frequency of interactions	Low	High	Low	High	High

What is IoT Suite?

Azure IoT Suite packages together multiple Azure services with custom extensions as preconfigured solutions.

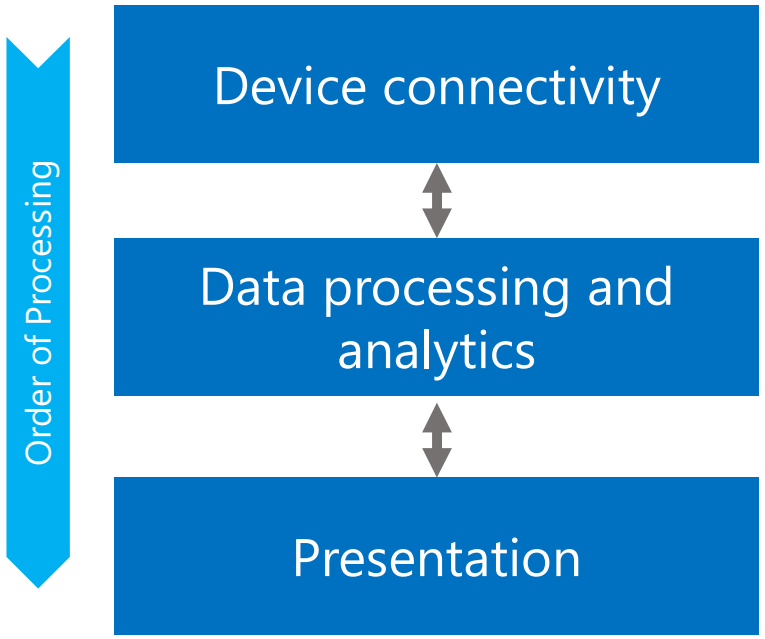
- Collect data from devices
- Analyze data streams in-motion
- Store and query large data sets
- Visualize both real-time and historical data
- Integrate with back-office systems

IoT Architecture in Azure



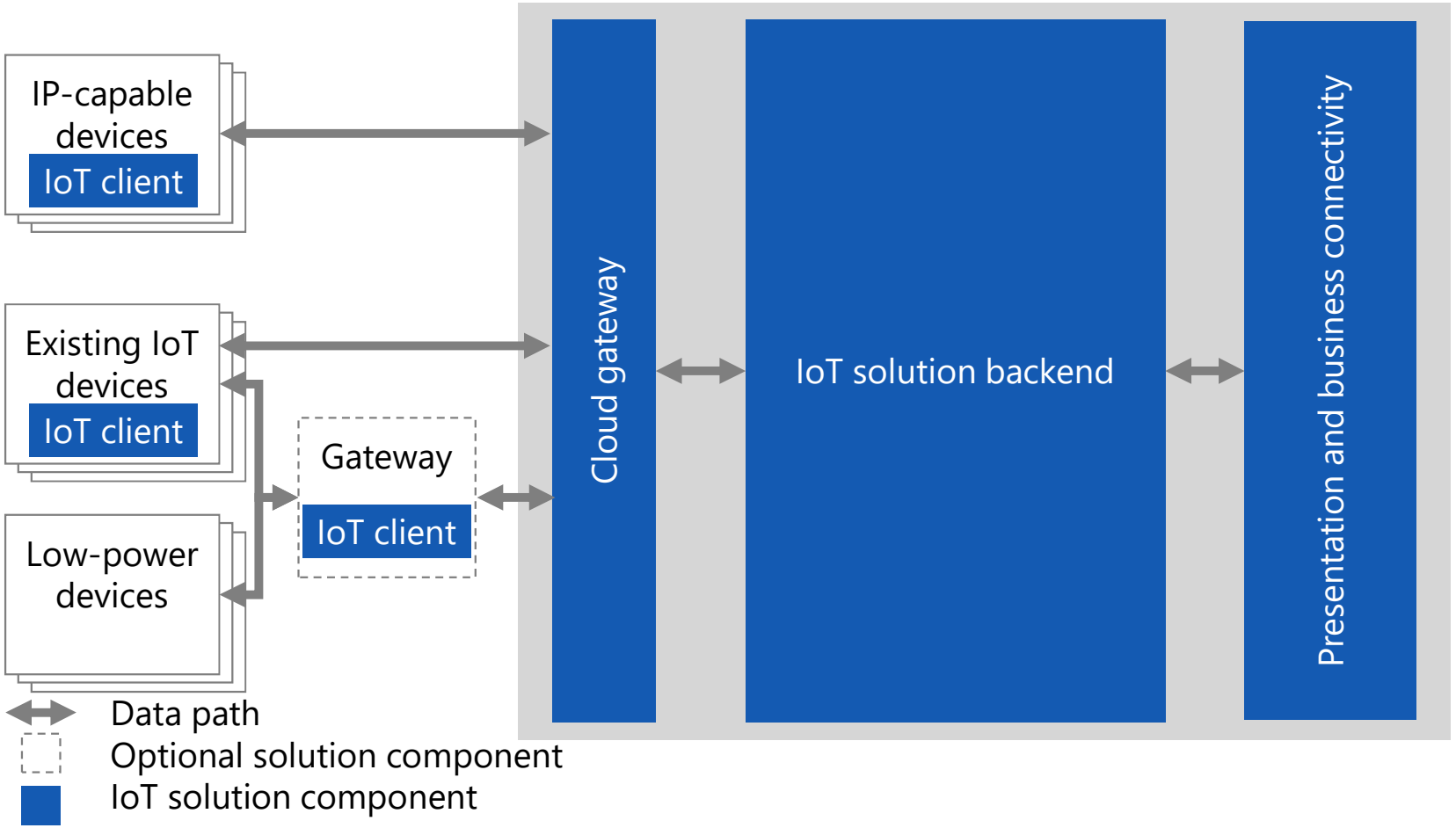
IoT in Azure

- Get started in minutes
- Connect any device
- Predict the future
- Automate to transform
- Cross platform
- Azure has the widest range of compatibility



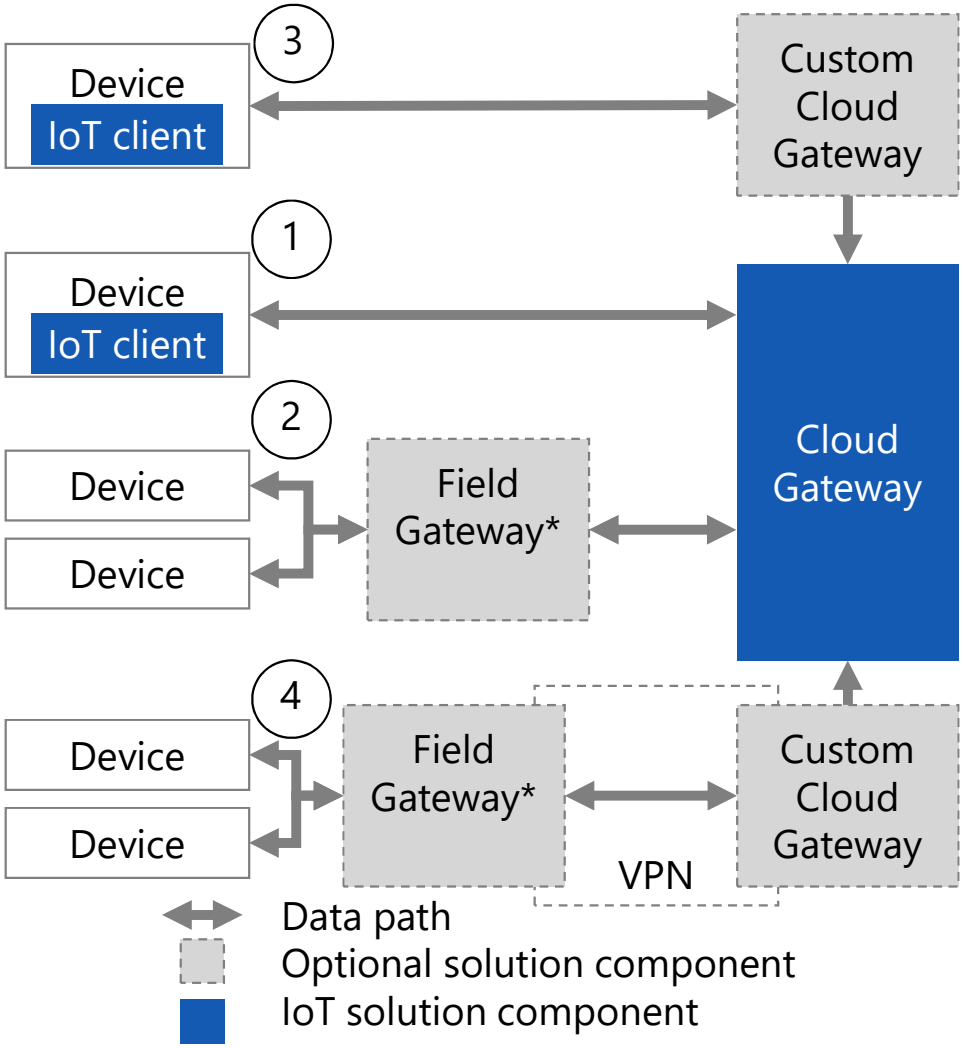
Connecting IoT Devices to Azure

Azure IoT Architecture



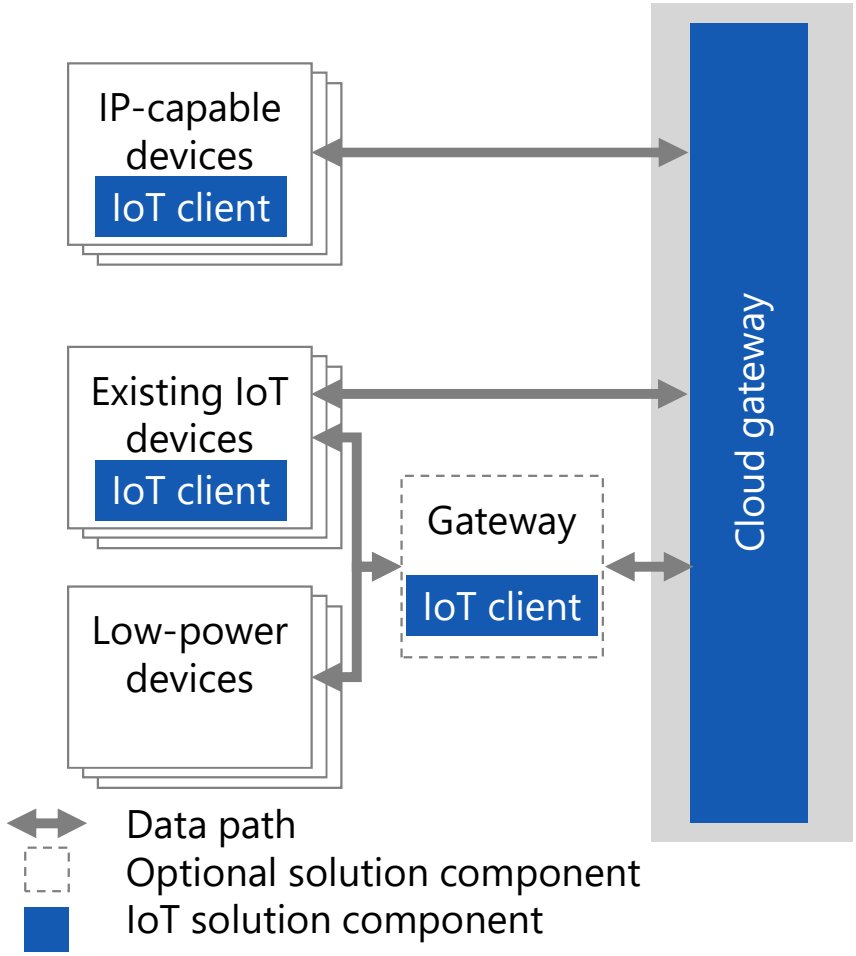
Device connectivity

1. Connect to directly the cloud gateway
2. Connectivity via a field gateway
3. Connect to custom cloud gateway
4. Connectivity via a field gateway and custom cloud gateway



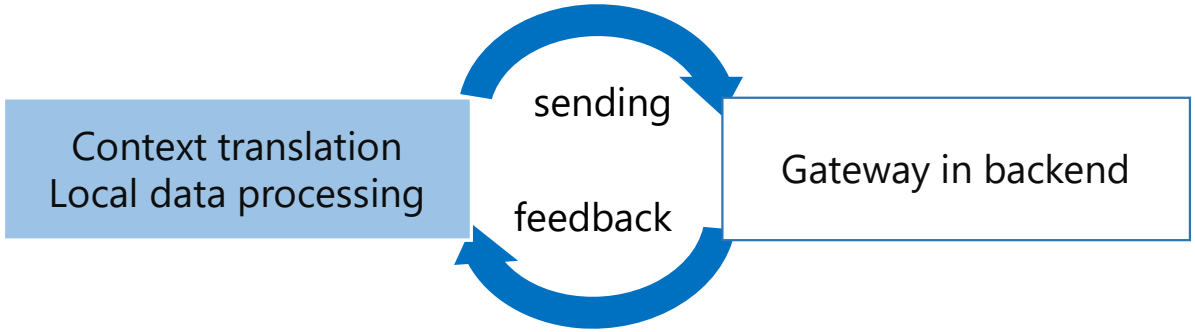
Device

- The feature is anyway to do something useful
  Ex) sensing, computing, communicating, acting
- Heterogeneous device support
- Target devices



Field Gateway

- Device-appliance or general-purpose software
- Local processing and control functions in devices

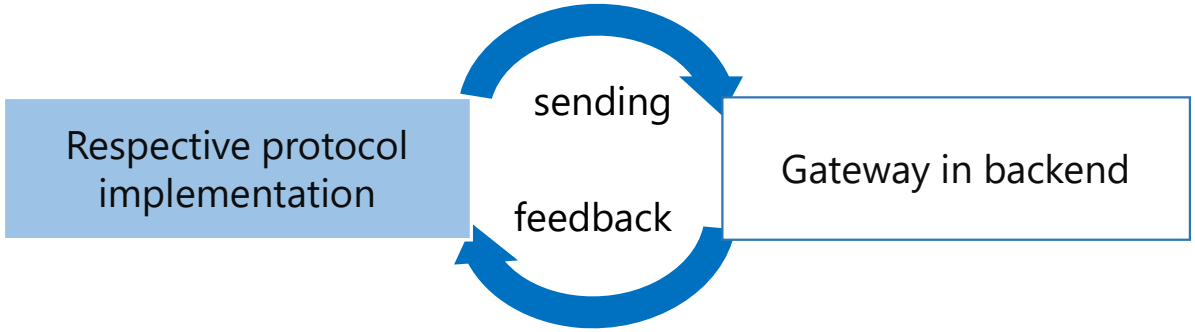


Cloud Gateway

- A system that enable s remote communication from and to devices or field gateways
- Handles communication between devices and a backend system

Custom Cloud Gateway

- Protocol adaptation and/or some form of custom processing before reaching the cloud gateway communication
- Message transformations or compression/decompression

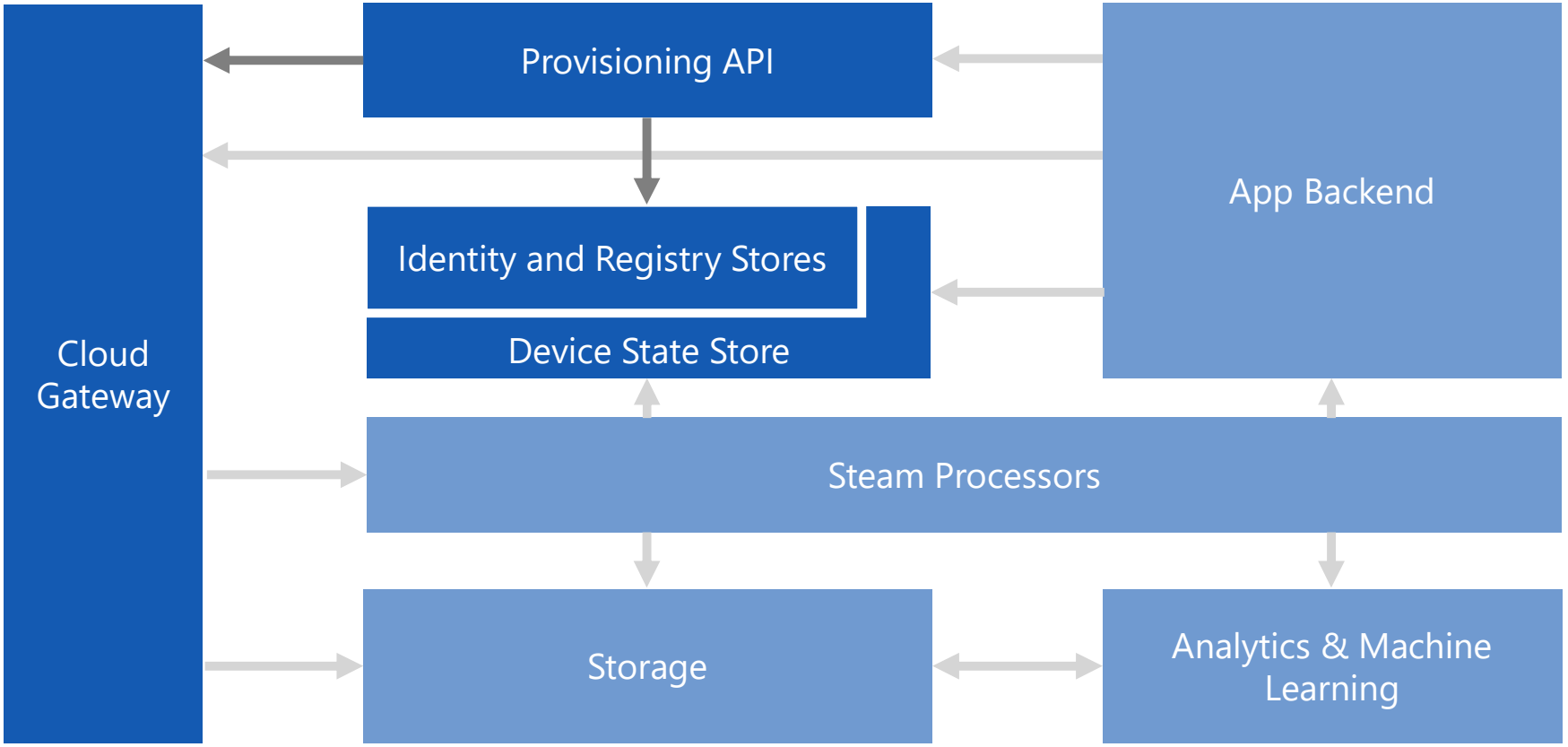


IoT Client

Three key patterns for client connectivity being used in IoT

- Direct connectivity from the device app/software layer
- Connectivity through agents
- Using client components integrated in the app/software layer of the device or gateway

Device Identity and Registry Store



Device Provisioning

Provisioning API is the common external interface for how changes are made on the device identity store and the device registry

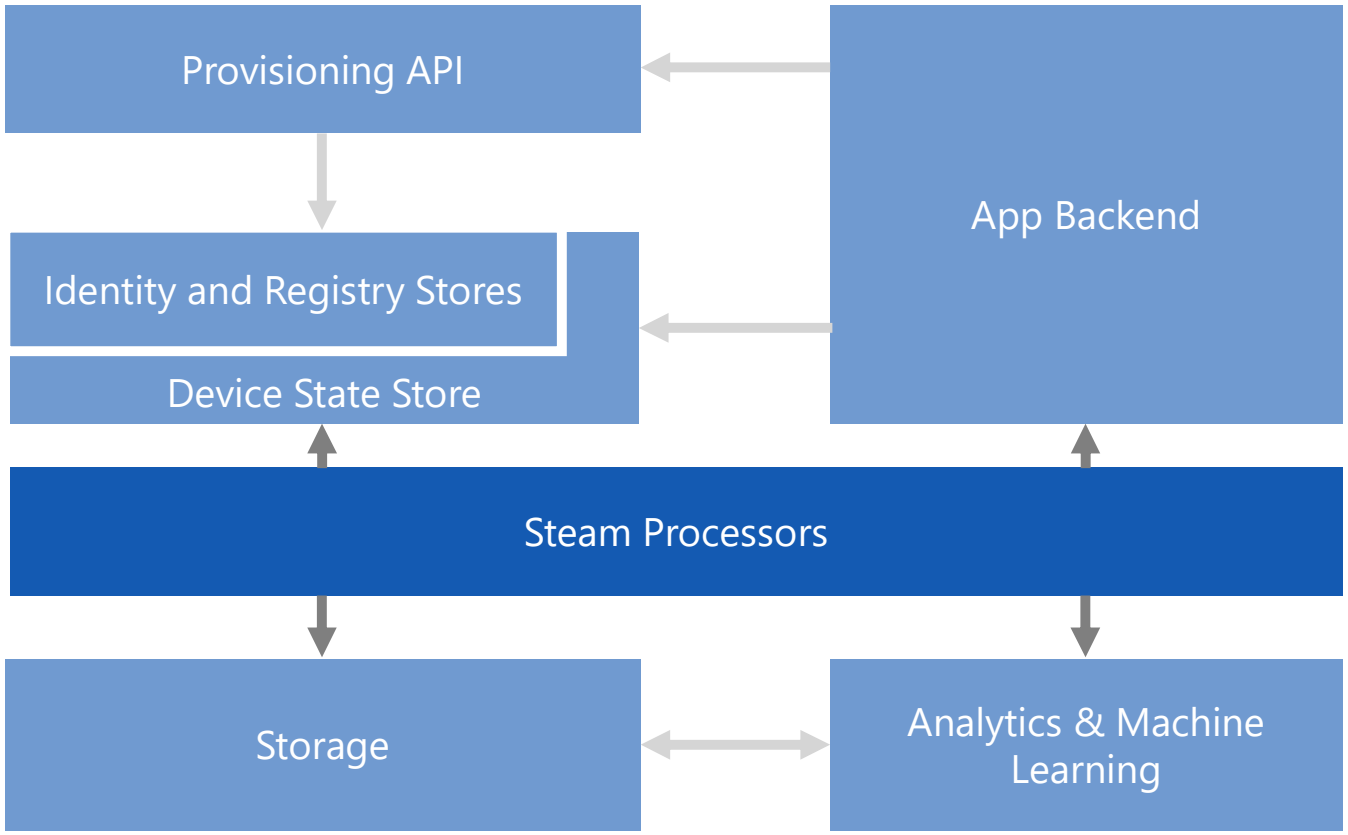
- Abstract interface with common gestures
- An implementation of that abstract interface for the identity and registry stores
- Processing individual and bulk requests for registering new devices and updating or removing existing devices

Device State Store

Operational data related to the devices resides in the device state store separate from the device registry

- The state store is an optional architectural element
- State store retains the raw stream of incoming events from the device
- Retains a last known values record that is a projection of the last observed values captured from the device

Stream Processor



App Backend

Implements the appropriate object models and abstractions for devices, groups of devices and business rules and actions

- Manages access and associations between devices and users
- Custom control logic of the solution, device discovery
- Visualization, device state management and command execution

Solution UX

- A website for UX for mobile and desktop App
- Solution and implements access to and visualization of device data and analysis results
- Integrate with interactive dashboards, which are a suitable form of visualizations for IoT

Business Systems Integration

The integration of the IoT environment into downstream business systems such as CRM, ERP, and line-of-business (LOB) applications

- Through business connectors or EAI/B2B gateway capabilities

Introduction to IoT Hub

Connecting Devices to the Cloud

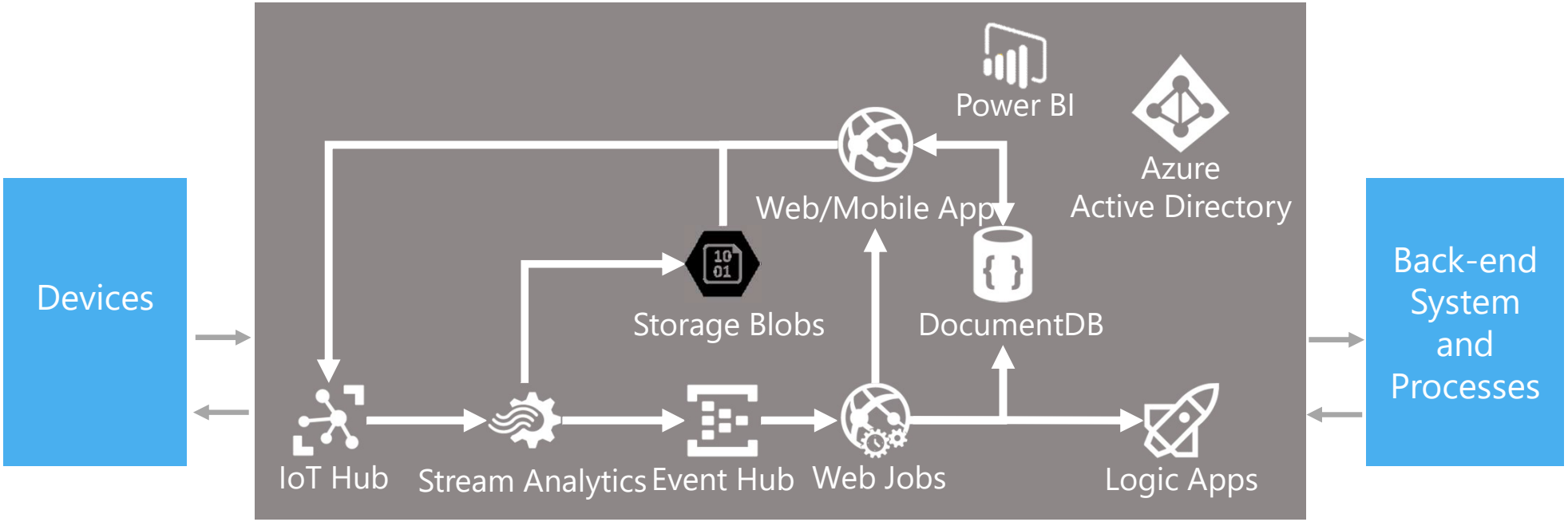
Challenges:

- Communication protocols
- Platform specificities
- Security
- Device identification
- Command and control
- IP capable device or not.

Solutions Map to Specific IoT Features

Solution	Data Ingestion	Device Identity	Command and Control	Rules and Actions	Predictive Analytics
Remote monitoring	Yes	Yes	Yes	Yes	-
Predictive maintenance	Yes	Yes	Yes	Yes	Yes

Remote Monitoring Preconfigured Solution Overview

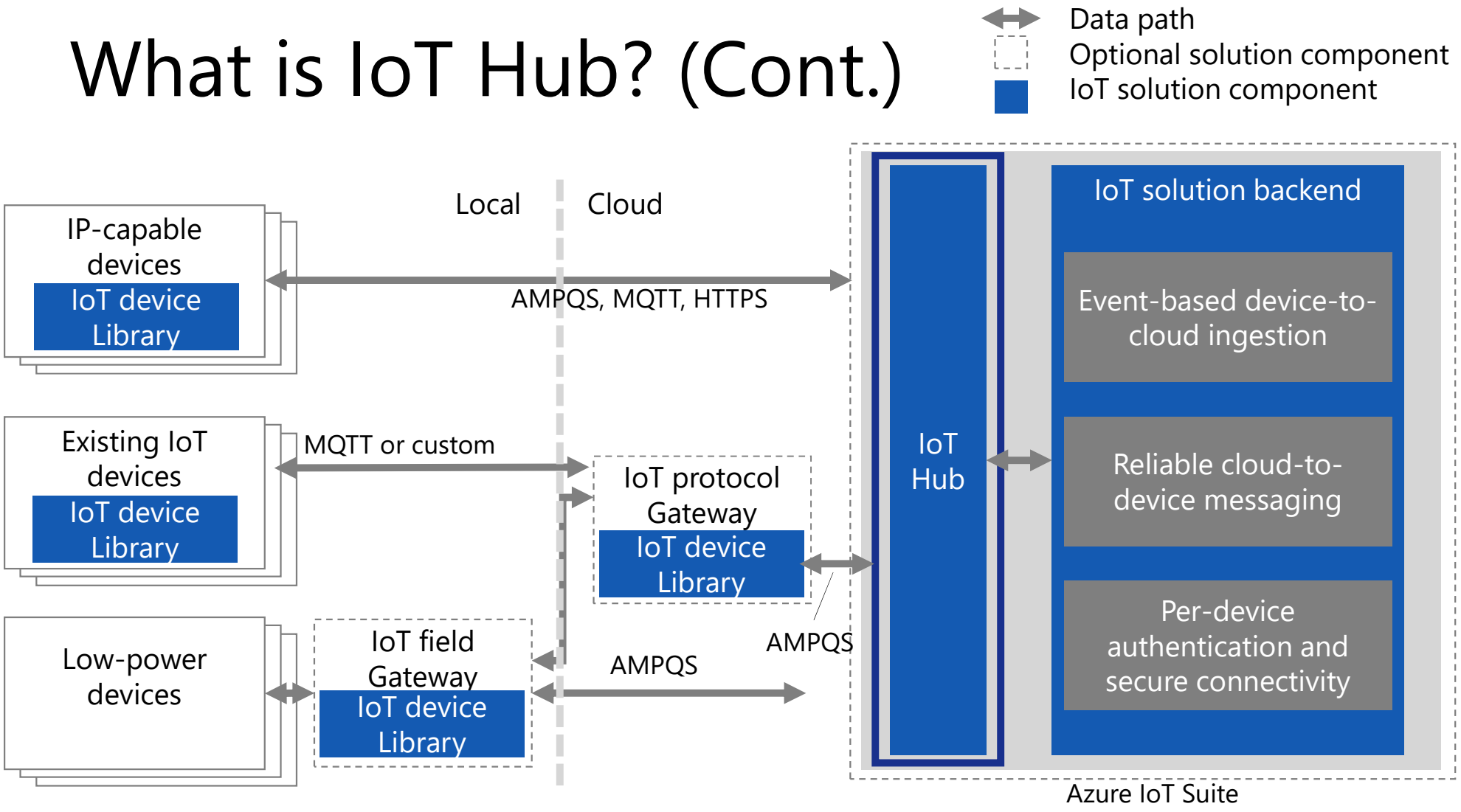


What is IoT Hub?

The gateway for device to connect to the cloud in Azure

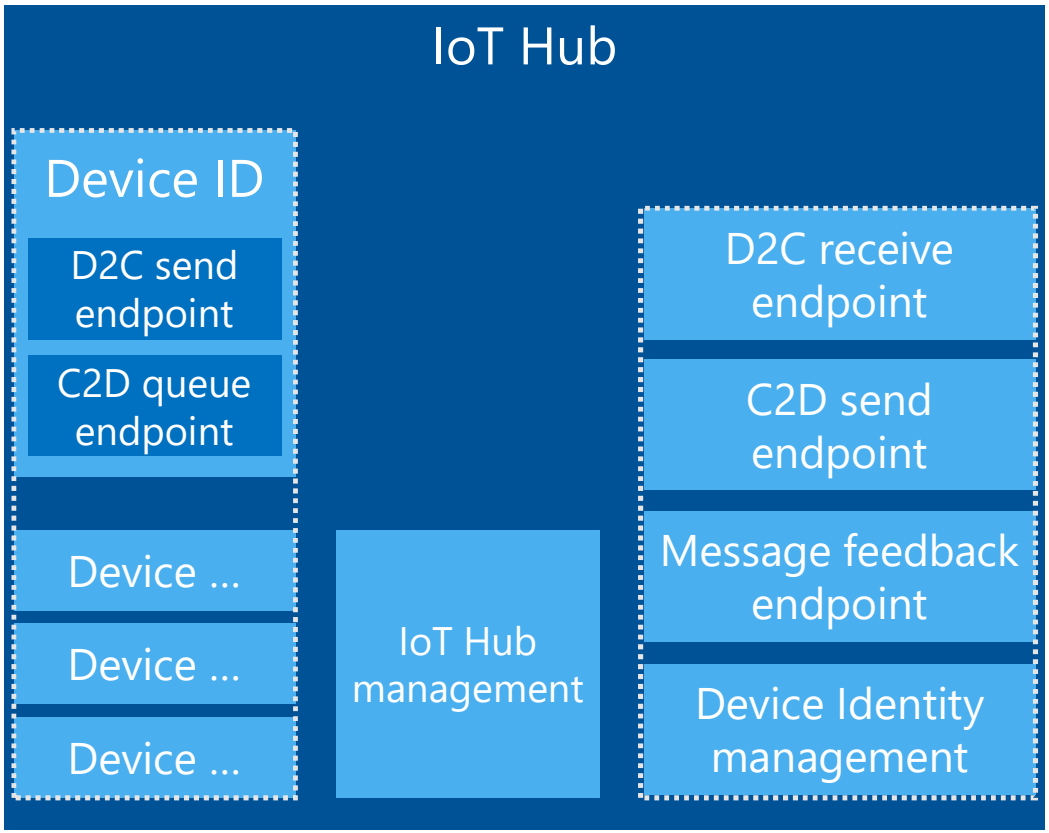
- Millions of simultaneously connect devices
- Per-device authentication
- High throughput device to cloud messaging
- Multi-protocol and platform

What is IoT Hub? (Cont.)



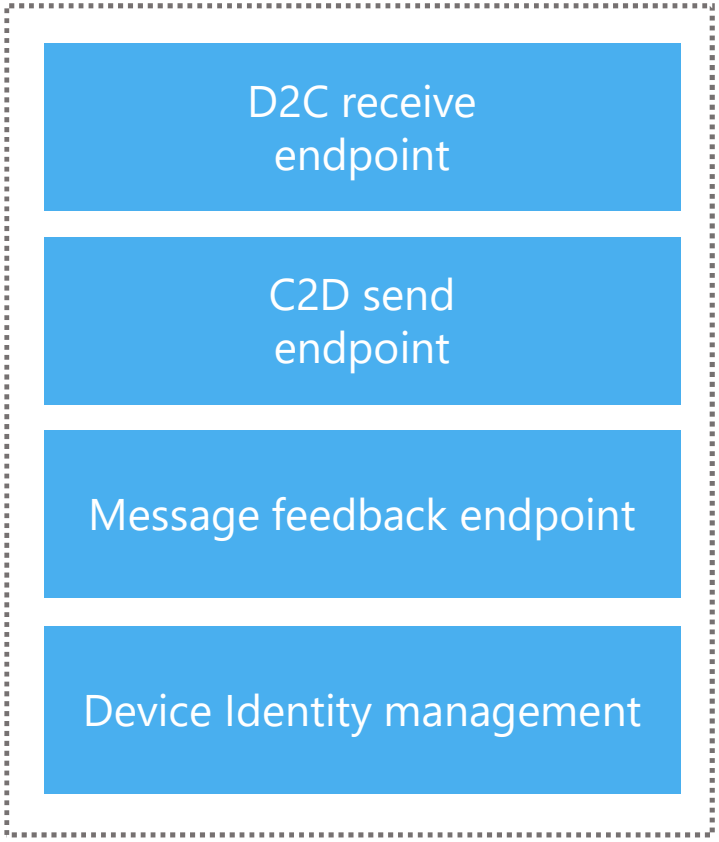
What is IoT Hub? (Cont.)

- For the device side
- For the service side
- IoT Hub Management



Service Side in IoT Hub

- Back-end receive from the D2C receive endpoint
- C2D send endpoints to send message to individual devices
- Feedback endpoint provides delivery status information
- Device Identity management provides secure connectivity between cloud and device



Why Use Azure IoT Hub

Benefits of IoT Hub

- Per-device authentication and secure connectivity
- Monitoring of device connectivity operation
- An extensive set of device libraries
- Scale

Why Use Azure IoT Hub (Cont.)

Benefits of IoT Hub

- IoT protocols and extensibility
- Event-based device-to-cloud ingestion
- Reliable cloud-to-device messaging or commands

What is an Azure Event Hub?

A managed platform service that provides a foundation for large-scale data intake

- Cloud-scale telemetry ingestion from websites, apps, and devices
- A message stream handling capability
- A component or service that sits between event publishers and event consumers

IoT Hub vs Event Hubs

Area	IoT Hub	Event Hub
Communication patterns	Enables device-to-cloud and cloud-to-device messaging.	Only enables event ingress
Protocol Support	Supports AMQP, AMQP over WebSockets, MQTT, and HTTP/1.	Supports AMQP, AMQP over WebSockets, and HTTP/1
Security	Provides per-device identity and revocable access control	Provides Event Hubs-wide shared access policies, with limited revocation support through publisher's policies.
Device SDKs	Provides device SDKs for a large variety of platforms and languages	.NET, and C. Also provides AMQP and HTTP send interfaces.
Scale	Support millions of simultaneously connected devices.	Up to 5,000 AMQP connections, as per Azure Service Bus quotas.

How to Create an IoT Hub in Azure Demo

Azure IoT Suite SDKs

Two types of SDKs:

- Device-facing - For devices and field gateway
  - Platforms : RTOS, Linux, Windows, Android, iOS…
  - Languages : C, Java, C#, Javascript
- Service-facing - For back-ends and cloud gateway
  - Languages : .NET C#, Java, Node

Streaming Analytics on Azure

Data Stream

A Data Stream is data in motion with continuous updates

- Two categories of data
  - Data at rest
  - Data in motion
- Data at rest
  - Typically a data warehouse
- Data in motion
  - Any data that is continuously updated

Data Analysis – Data at Rest

Data at rest query provides a static answer

- Imagine you have data on a particular highway
- Data at rest queries might include
  - How many cars utilized the freeway in a particular month
  - What was the total amount of resources spent on repairs for a particular year

Data Analysis – Data in Motion

Data at motion query never ends

- Imagine you have cameras monitoring a particular highway
- Data in motion queries might include
  - What is the current percentage of trucks utilizing the freeway
  - i.e. current count of trucks passing / current count of vehicles passing by
- In this query, the percentage continues to fluctuate, and the query never ends

Stream Analytics Example

Analyze streaming data in real-time

- Personalized, real-time stock trade analysis
- Real-time fraud detection
- Ingestion and analysis of data generated by sensors and actuators
- Web clickstream analytics
- Customer relationship management (CRM) applications monitoring real-time customer experience

What is Azure Stream Analytics (ASA)?

ASA is a PaaS that provides a real-time event processing engine

- Platform as a Service
  - Maintenance and management of platform maintained by vendor
  - Users can scale their operations with events up to 1GB/sec to match their current requirements
  - Users pay as they go based on volume of events processed
- Allows end-user to concentrate on development

ASA Connectivity

ASA connects to many input and output sources

Input

- Azure Event Hub
- Azure IoT Hubs
- Azure Blob Service

Output

- Azure Storage Blobs or Tables
- Azure SQL DB
- Azure Event Hub
- Azure Service Bus
- Power BI

End-to-End Architecture Overview