How to connect to AWS IoT Core using Amazon FreeRTOS for Embedded Devices – Hands-on Workshop using STM32L4 Discovery Kit IOT Node

AME Marketing

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Standard Technology Partner

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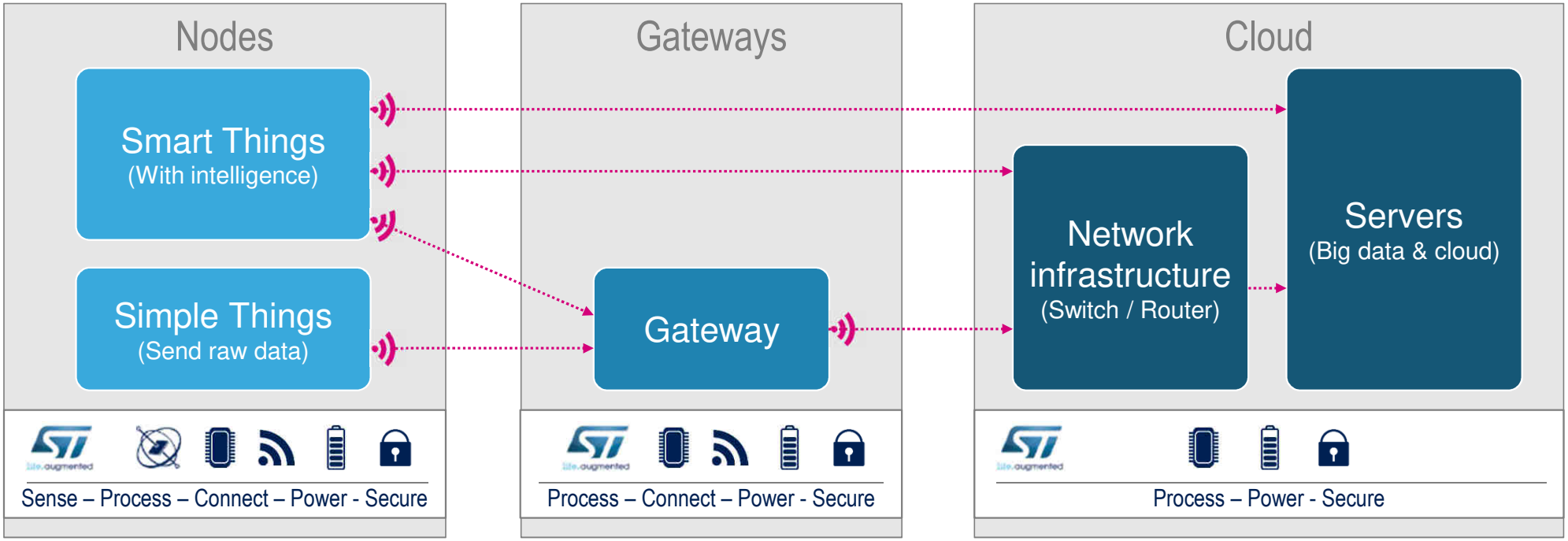
Technology Tour 2019

Schaumburg, IL | April 25

The IoT Movement

IoT is a movement where any system is able to leverage the Internet and its ecosystem

Cloud computing – Low cost embedded computers – Explosion of reliable wireless connectivity – Rapid innovation of low cost sensors



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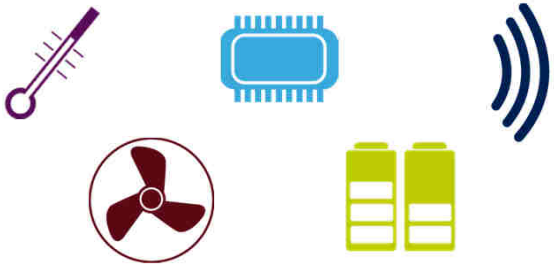
ST Has all the Building Blocks for the IoT

"Thing" you know how to build.

Plus what "Smart"?



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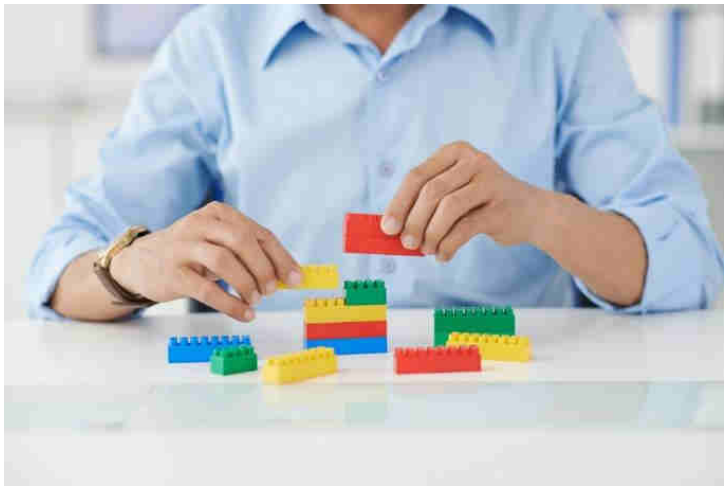

Pieces from different sources and and no building instructions…

...or

Supporting the IoT Movement

Connect

Sense

Translate

Move
Actuate

Power

Secure

Process

SensorTile

BlueCoin

SmarTAG

Discovery Kit IoT Node

STM32 Nucleo Development
& Expansion boards

Pre-integrated SW for vertical applications

Smart Things

Smart Home

Smart City

Smart Industry

Development Ecosystem

Code generators

Prototyping
software

IDE
Development
environments

Debug
solutions

Simulation
and analysis tools

On-line
design tools

ST Community

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Partner
Program

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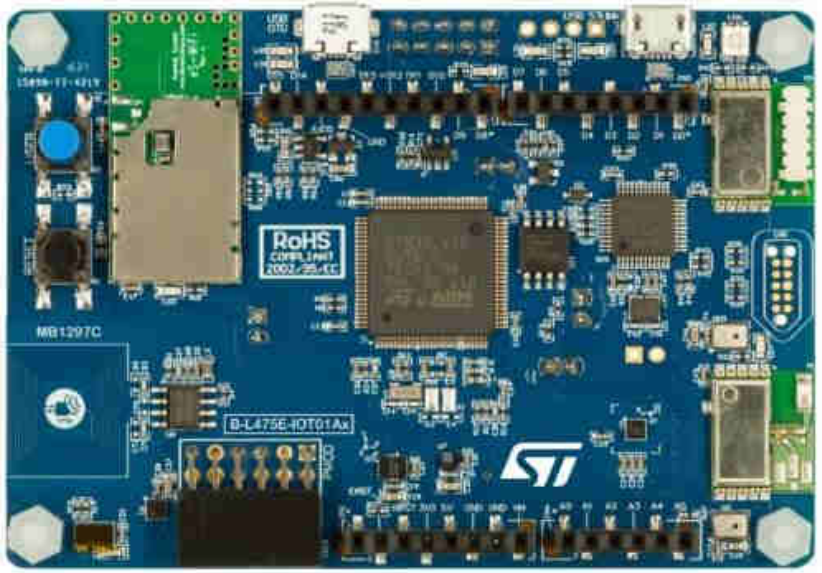
STM32L475 Discovery Kit IoT Node

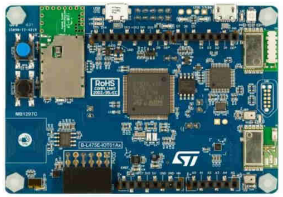
B-L475E-IOT01A

- SW Libraries for STM32L4 MCU & Sensors
- Low-power long-range communication (SubGHz)
- Direct Wi-Fi connection to cloud servers
- Environmental awareness: humidity, pressure, temp
- Detection hub: motion, proximity, audio



Workshop Deliverables

- For the workshop ST will provide



Discovery Kit IoT node

https://www.st.com/content/st_com/en/products/evaluation-tools/product-evaluation-tools/mcu-mpu-eval-tools/stm32-mcu-mpu-eval-tools/stm32-discovery-kits/b-l475e-iot01a.html

USB 2.0 A-Male to Micro B Cable

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STM32L4 Discovery Kit IoT Node

- STM32L4 MCU enables your IoT projects with the combination of ultra-low power and high performance
- STM32L4 Discovery Kit IoT is a compact, yet powerful board to explore various connectivity options
- Next Steps
  - You can add BLE, NFC and sensors features to the Amazon FreeRTOS project to create an application that can connect to the cloud and also has short range connectivity with your smartphone
  - Post your projects or ideas on the ST Community website to gather feedback and get support: https://community.st.com/community/share-your-activities/pages/overview
  - Refer to Amazon FreeRTOS user guide for more examples.

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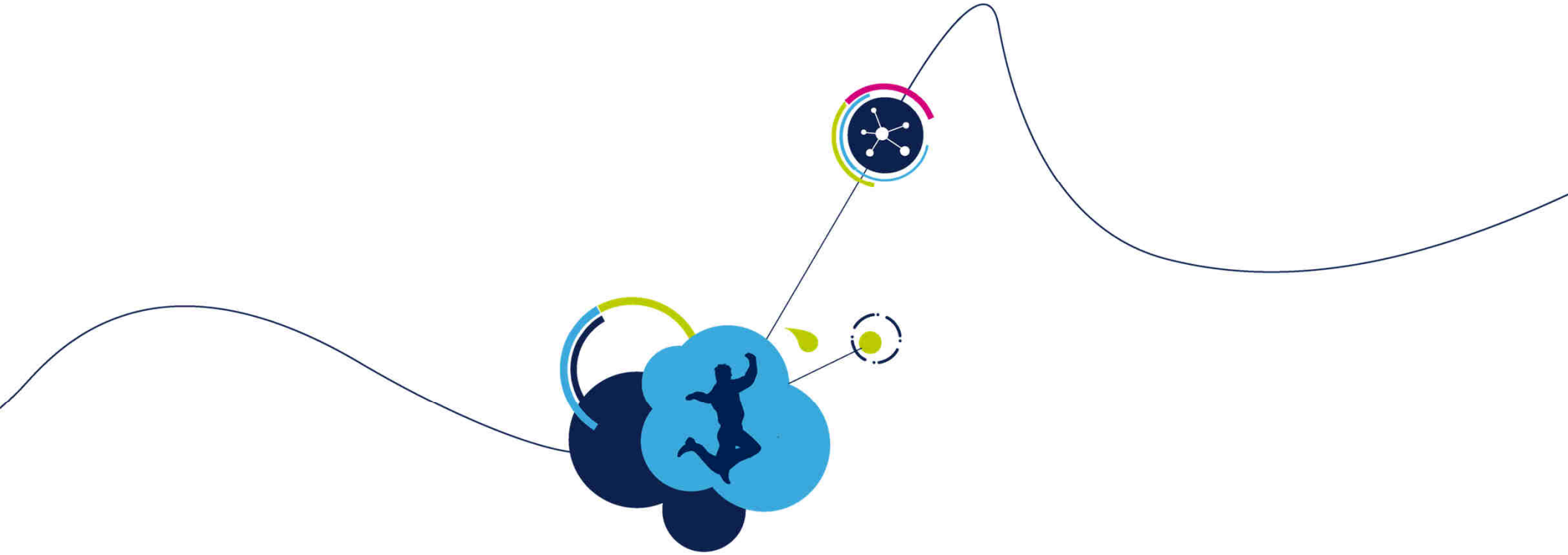

Software and Other Pre-requisites

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Software and Others Pre-requisites

Windows (Win7, Win8, Win10)

- **ST-LINK, ST-LINK/V2, ST-LINK/V2-1 USB driver signed for Windows7, 8, 10:** STSW-LINK009 (https://www.st.com/en/development-tools/stsw-link009.html)
  - NOTE: Required for Window 7
- **Serial line monitor**: Tera Term (https://ttssh2.osdn.jp/)
  - Install from USB `.\Windows\teraterm-4.99.exe`

System Workbench for STM32

(requires registration to openstm32.org)

http://www.openstm32.org/Downloading+the+System+Workbench+for+STM32+installer

- install_sw4stm32_win_64bits-v2.5.exe
- install_sw4stm32_macos_64bits-v2.5.run
  - Warning: To run System Workbench for STM32 on MAC OSX systems, XCode may be required. To download it, please refer to the Apple developer website (registration as Apple Developer is required)
  - The downloaded installer is an executable binary file. Your web browser might have removed the execution right of the file. Please set the execution right to the installer file (chmod 755 install_sw4stm32.run then ./install_sw4stm32.run) OR Launch it with /bin/bash (/bin/bash install_sw4stm32.run)
  - If an error message saying the installer "is damaged and can't be opened. You should move it to the Trash.", please modify the installation access right in the Gatekeeper. On latest version of MAC OSX, go in the terminal:

```
#To disable
sudo spctl --master-disable
#To set the Gatekeeper access right back
sudo spctl --master-enable
```

  - On older version of MAC OSX:
  - Go in the "System Preferences" > "Security & Privacy", then select "Allow downloaded app from :" "Anywhere". When the installation is done, restore the setting value back at "Mac App Store and identified developers"
- install_sw4stm32_linux_64bits-latest.run
  - The installer in GUI-mode requires gksudo. On Ubuntu, gksudo is in package gksu, that you can install by sudo apt-get install gksu. If gksudo is not installed, the installer can still be launched in command-line.
  - The downloaded installer is an executable binary file. Your web browser might have removed the execution right of the file. Please set the execution right to the installer file (chmod 755 install_sw4stm32.run then ./install_sw4stm32.run) OR launch it with /bin/bash (/bin/bash install_sw4stm32.run)

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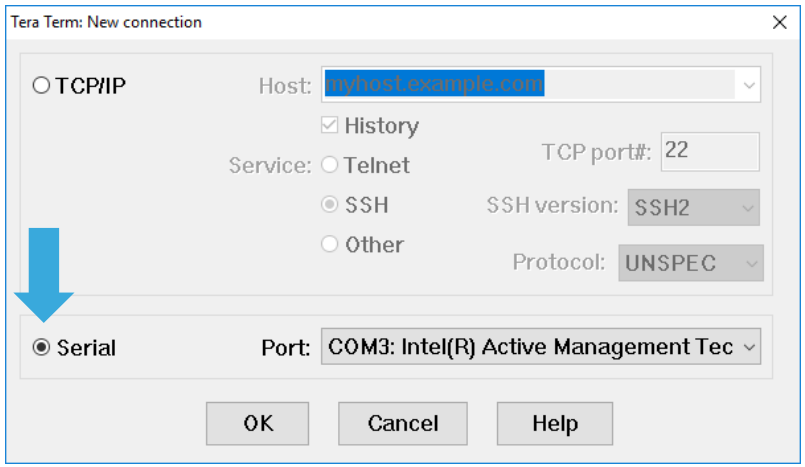
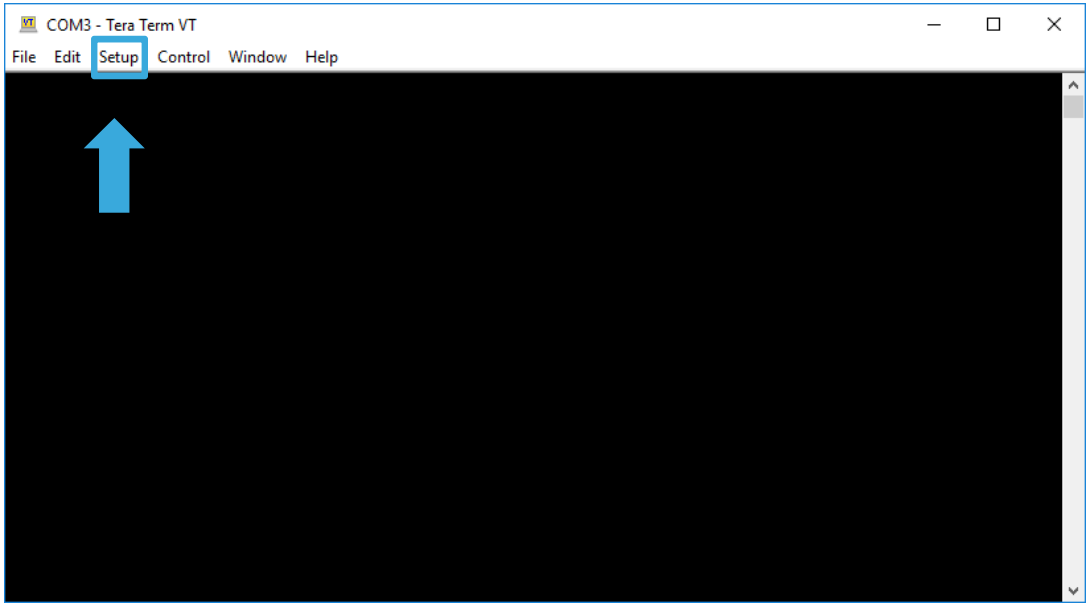
Tera Term Setup





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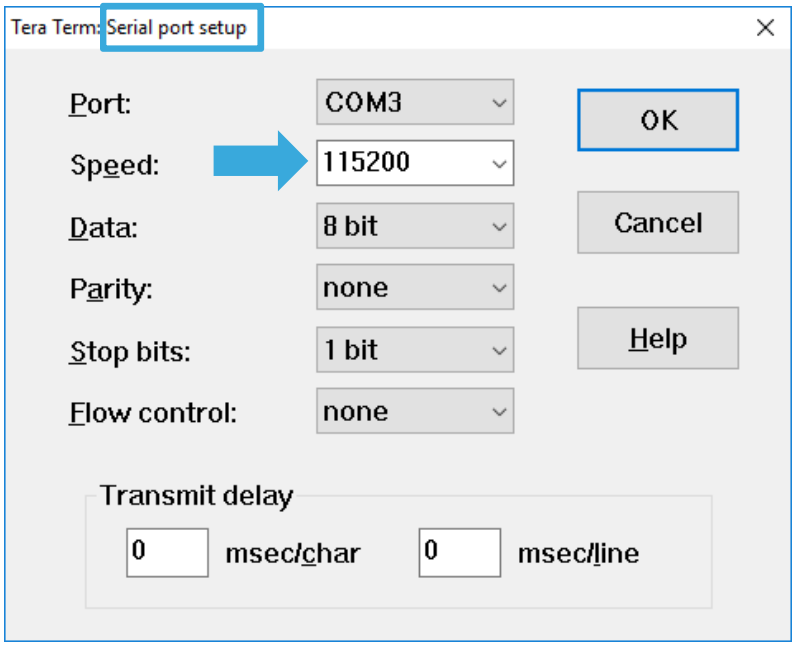
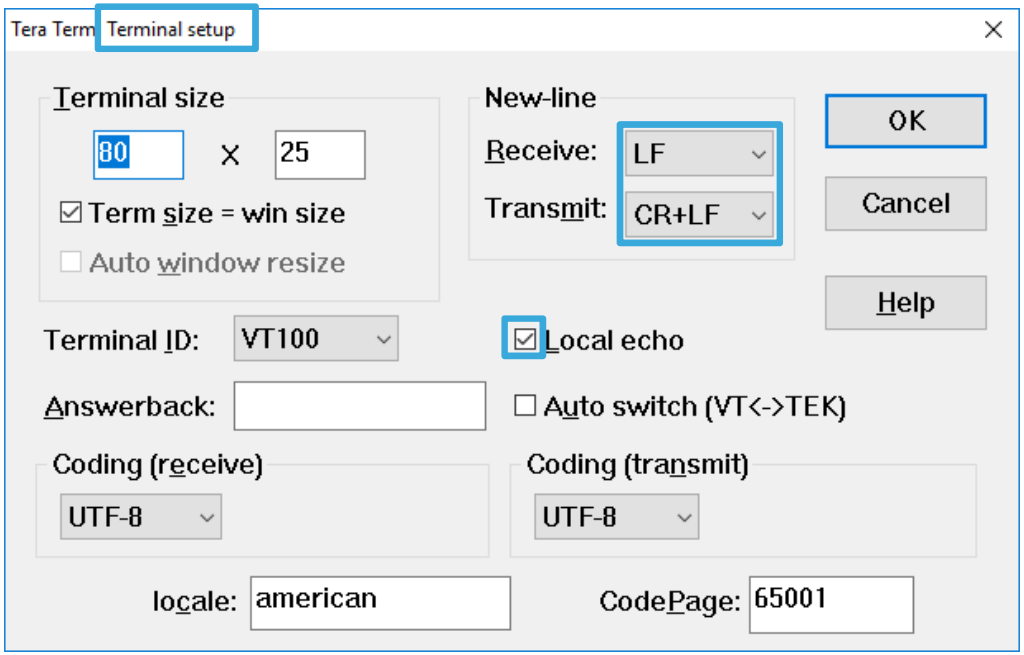
Tera Term Setup





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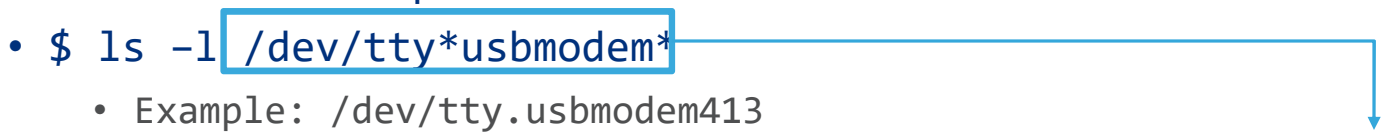
Software and Others Pre-requisites

Mac OS: PicoCom

Serial line monitor: PicoCom or Screen

- Launch Spotlight by pressing Cmd + Space. Type terminal and select the Terminal app.
- In the Terminal window, enter the commands
  - `$ brew install picocom`
  - `$ ls -l /dev/tty*usbmodem*`
    - Example: /dev/tty.usbmodem413
  - `$ picocom --imap lfcrlf -b 115200 -p 1 -d 8 -c <usb device file>`
    - Example: `$ picocom --imap lfcrlf -b 115200 -p 1 -d 8 -c /dev/tty.usbmodem413`



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Software and Others Pre-requisites

Mac OS: Screen (native app)

Serial line monitor: PicoCom or Screen

- Launch Spotlight by pressing Cmd + Space. Type terminal and select the Terminal app.
- In the Terminal window, enter the command: `ls /dev/cu.usb*`
- In the list of devices, look for a device that contains `cu.usbserial` or `cu.usbmodem`; in the example below IoT DK is mapped to `/dev/cu.usbmodem1413`
- Launch the from the terminal the `screen` utility by entering the command:

```
cesmosrv03:hack marco$ ls /dev/cu.usb*
/dev/cu.usbmodem1413
cesmosrv03:hack marco$ screen -L /dev/cu.usbmodem1413 115200 -L
```

usb device name

Serial terminal baudrate

- The `screen` command will open a serial terminal connected to the device. Reset the board to see log messages from the device

Software and Others Pre-requisites

Linux (Ubuntu)

Serial line monitor: Putty or Picocom

- Putty
  - `$ sudo apt-get update (This command updates the Ubuntu package list with latest one)`
  - `$ sudo apt-get install -y putty`
- Picocom
  - `$ sudo apt-get install picocom`
  - `$ ls –l /dev/tty*usbmodem*`
    - Example: /dev/tty.usbmodem413
  - `$ picocom --imap lfcrlf -b 115200 -p 1 -d 8 -c <usb device file>`
    - Example: $ picocom --imap lfcrlf -b 115200 -p 1 -d 8 –c /dev/tty.usbmodem413

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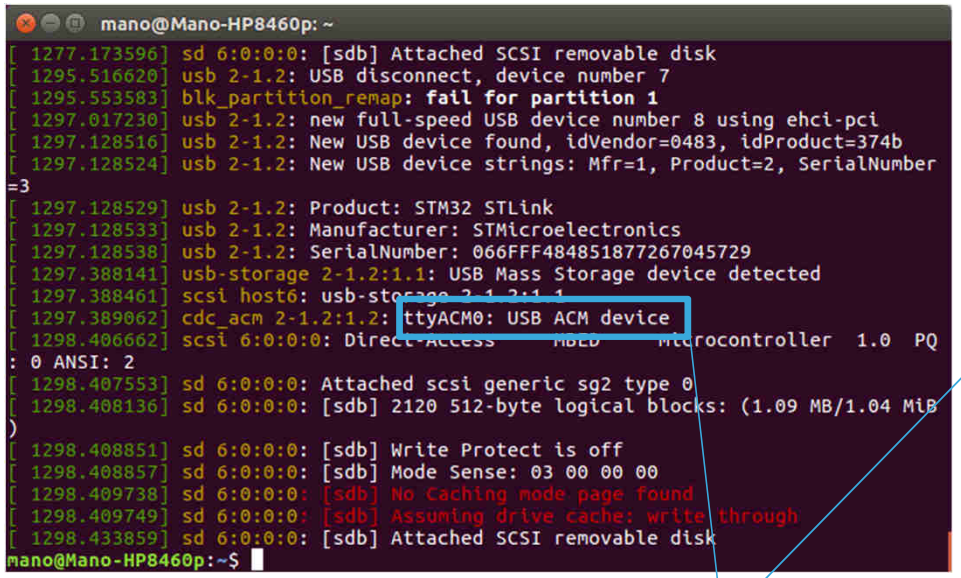
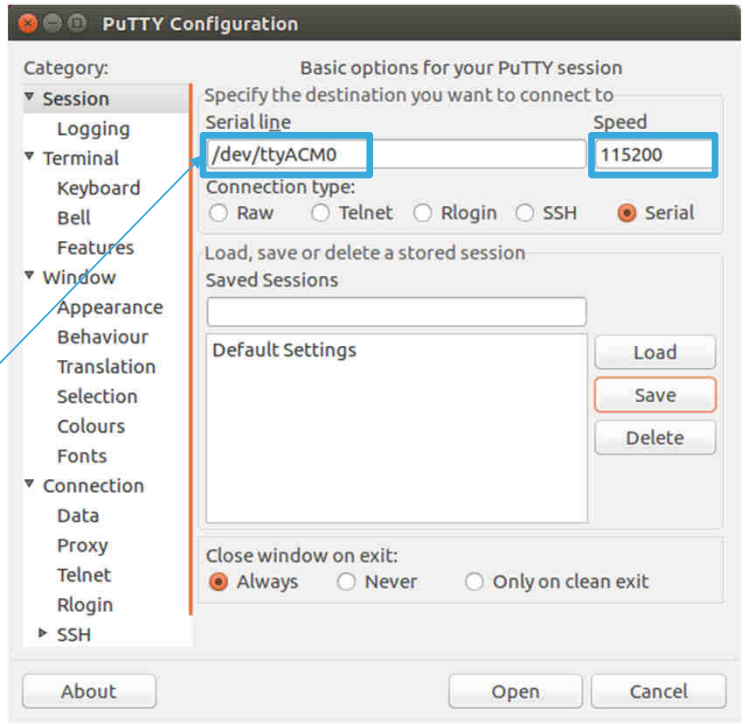
Open and Configure Serial Terminal (Putty)

- Open a Linux terminal and enter command: `dmesg`
- Open Putty



Note down device name for Discovery Kit



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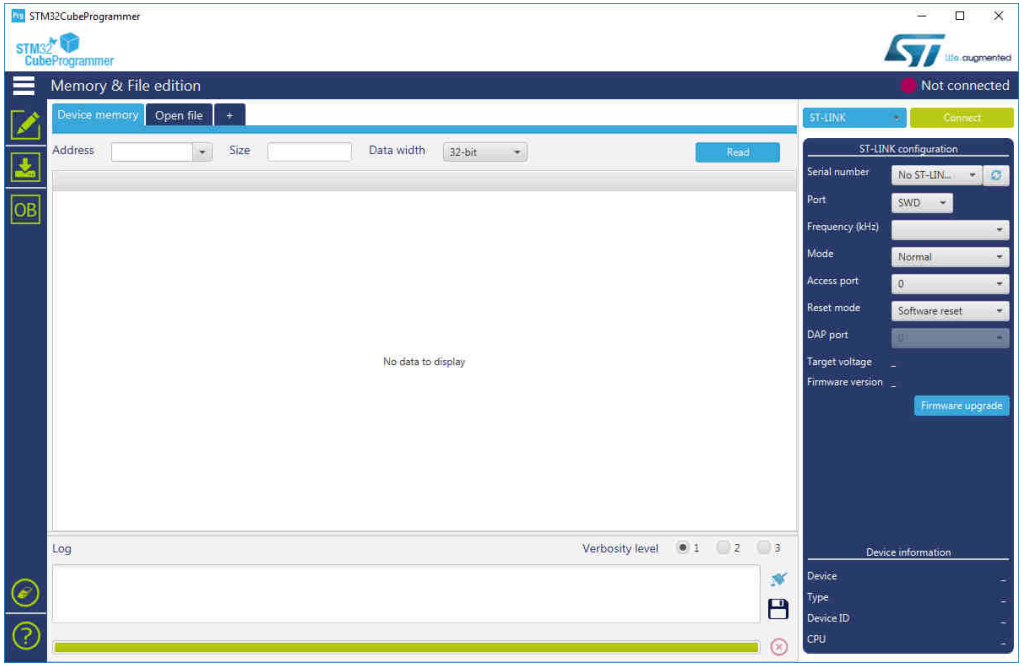
STM32CubeProg

- STM32CubeProgrammer (STM32CubeProg) is an all-in-one multi-OS software tool for programming STM32 products.
- https://www.st.com/content/st_com/en/products/development-tools/software-development-tools/stm32-software-development-tools/stm32-programmers/stm32cubeprog.html



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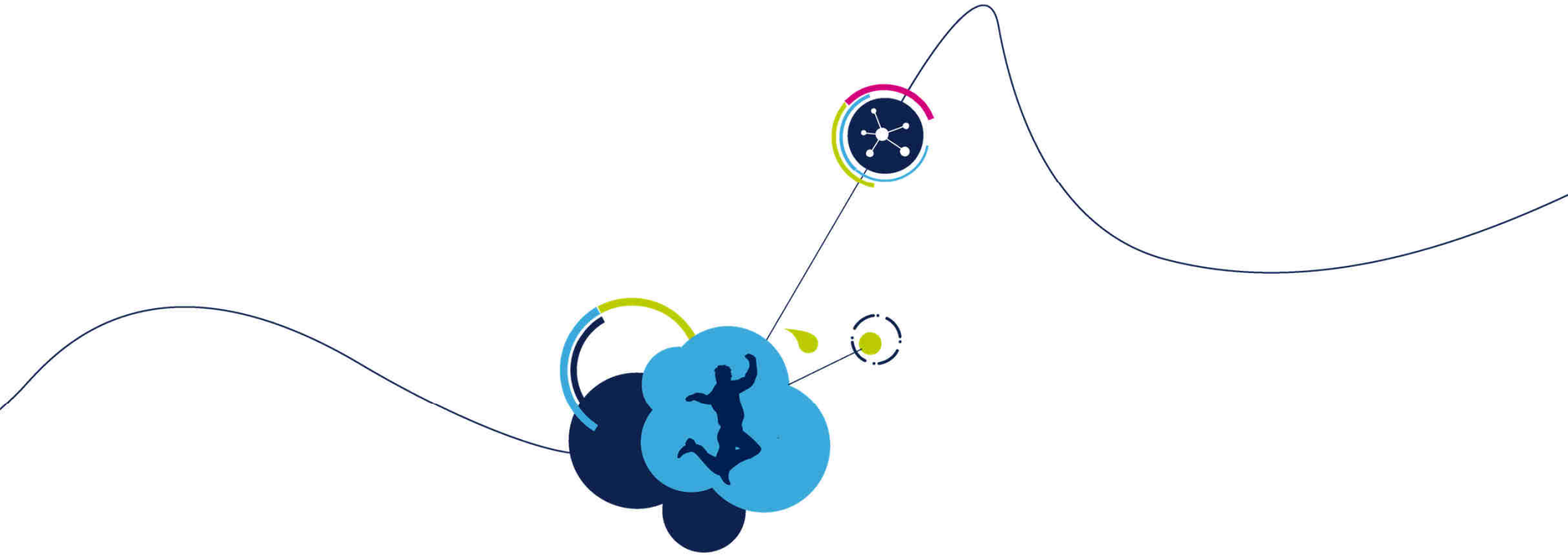

Amazon Web Services

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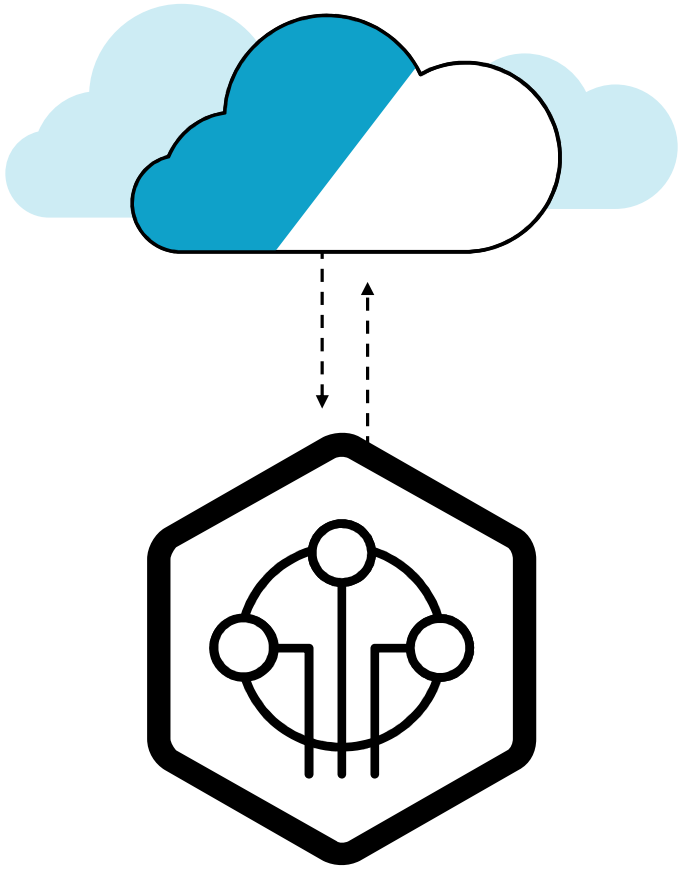
IoT on AWS



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If you knew the state of everything and could reason on top of that data...

what problems would you solve?

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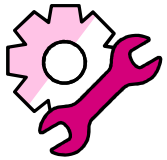
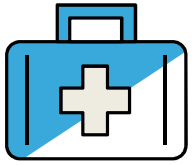
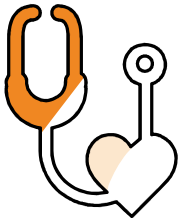
What customers are doing with AWS IoT



Predictive maintenance

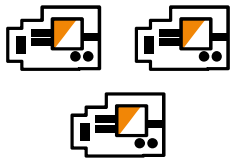


Wellness &
health solutions

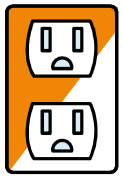


Remote patient monitor

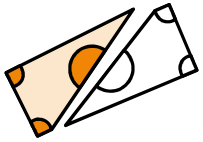
Connected buildings
& city systems



Maintain
device fleets



Monitor energy
efficiency



IoT payment &
connected commerce

Safeguard manufacturing
facilities

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Nobody just buys IoT technology…

they seek business outcomes

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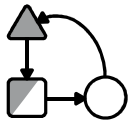
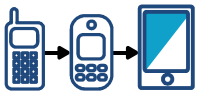
Business outcomes with IoT



New services & business models



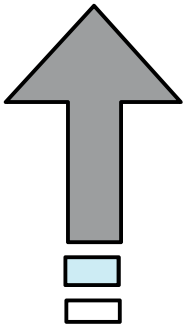
Products that get better with time

Better relationship with customers

Increased efficiency

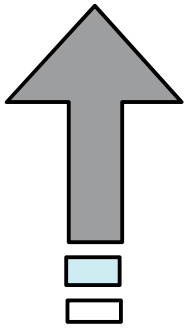
Intelligent decision making

Data driven discipline



Revenue growth

IoT data drives business growth



Operational efficiency

IoT data decreases OpEx

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IoT solutions are complex & multidimensional

Onboard, provision, manage

Connect, communicate, secure

Analyze, visualize, act

Engage, empower, delight

Transform, shift culture

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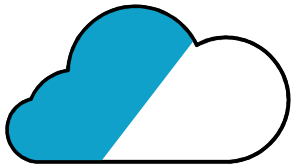
Our concept of IoT

Things
Sense & Act

Cloud
Storage & Compute



Intelligence
Insights & Logic →
Action

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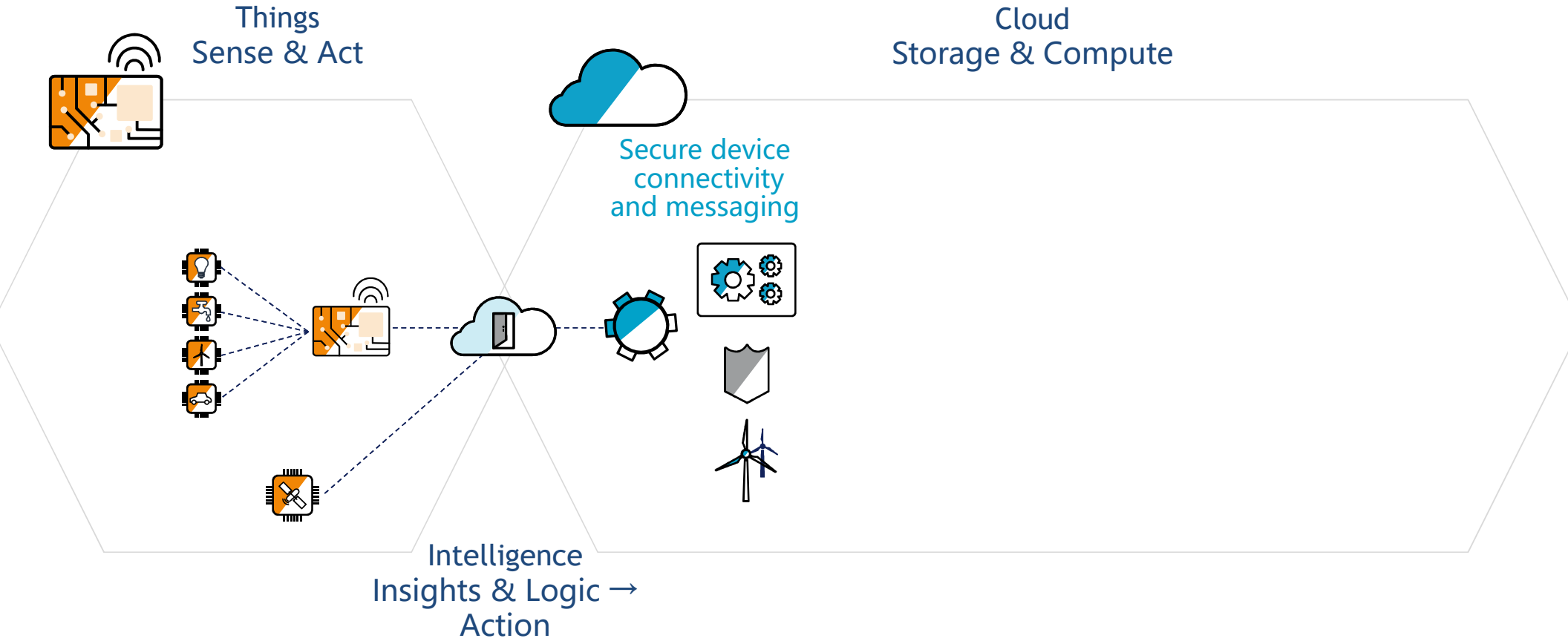
AWS IoT Architecture



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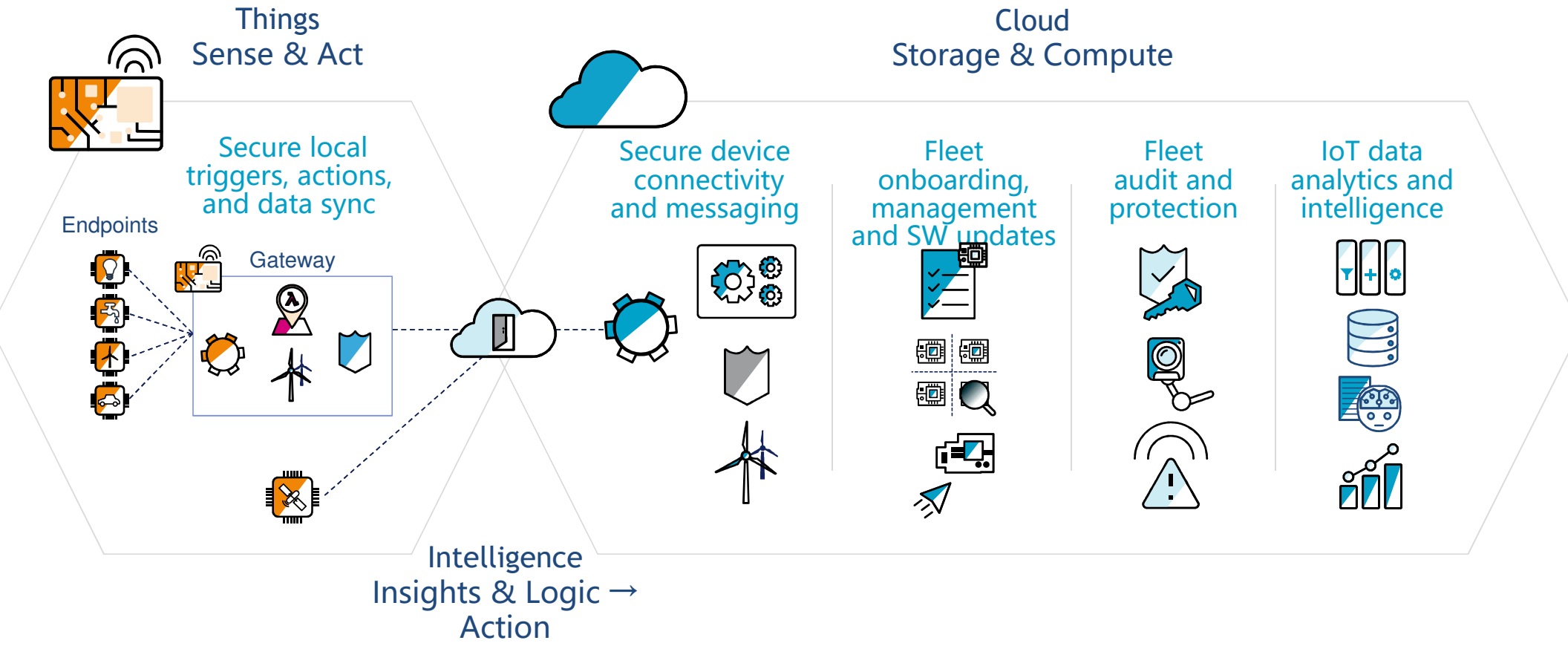
AWS IoT Architecture



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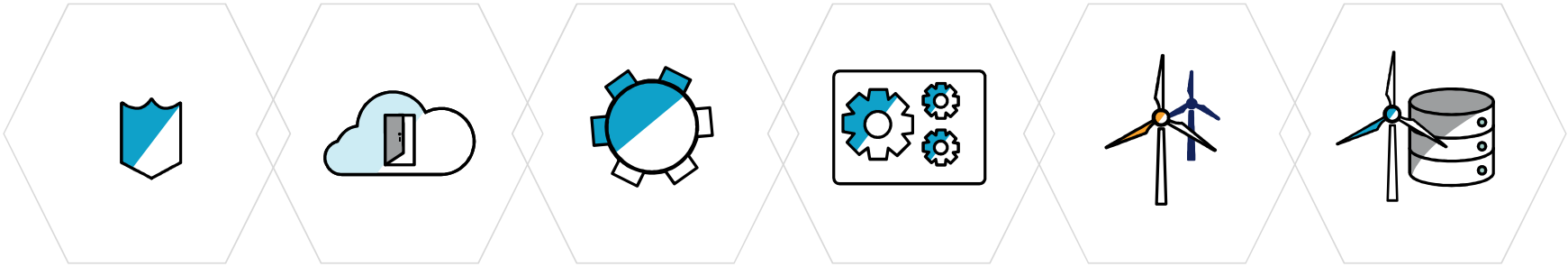
AWS IoT Core

Secure Device Connectivity and Messaging



Identity Service

Device Gateway

Message Broker

Rules Engine

Device Shadow

Registry

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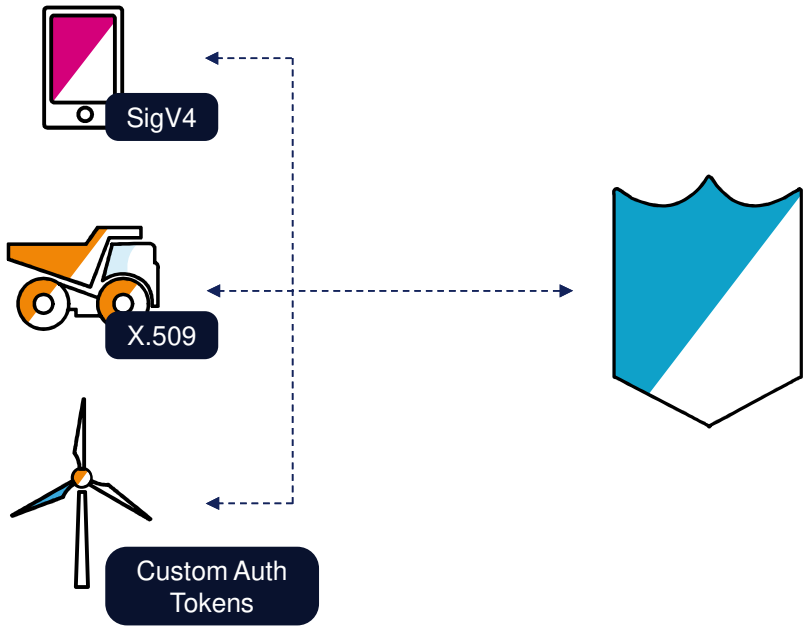
Identity Service

- Bring your own Root CA and certs
  or let AWS IoT Core generate certificates for you
- Automatic device provisioning with Just-In-Time Registration
- Flexible and fine-grained access control with IoT policies
  - Policies can be associated with identities or registry items
  - Can control access all the way down to the MQTT topic level



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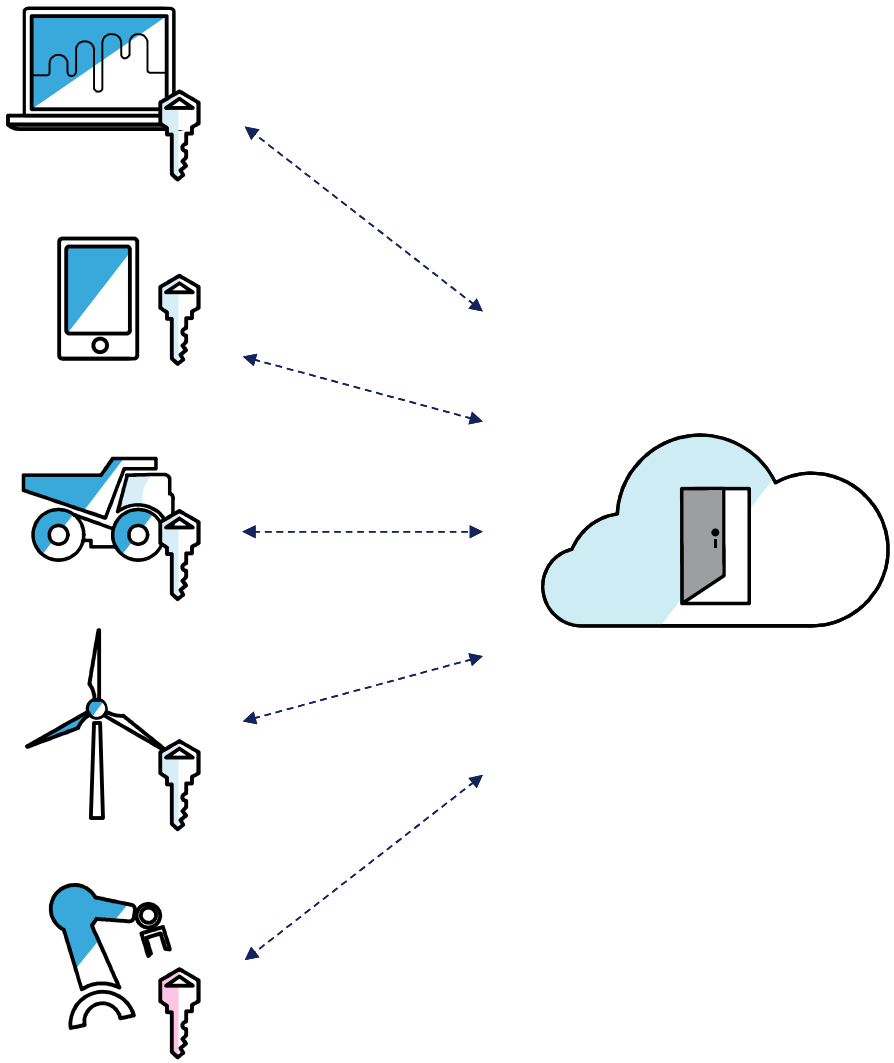
Device Gateway

- Entry point into the cloud for IoT devices
- Long-lived connections for bidirectional communication
- Support for multiple protocols including MQTT, WebSockets, HTTP
- Supports SigV4, X.509 and token based authentication (via Custom Authorizors)
- Secure communications over TLS 1.2
  - Support for numerous AES and ECDHE cipher suites



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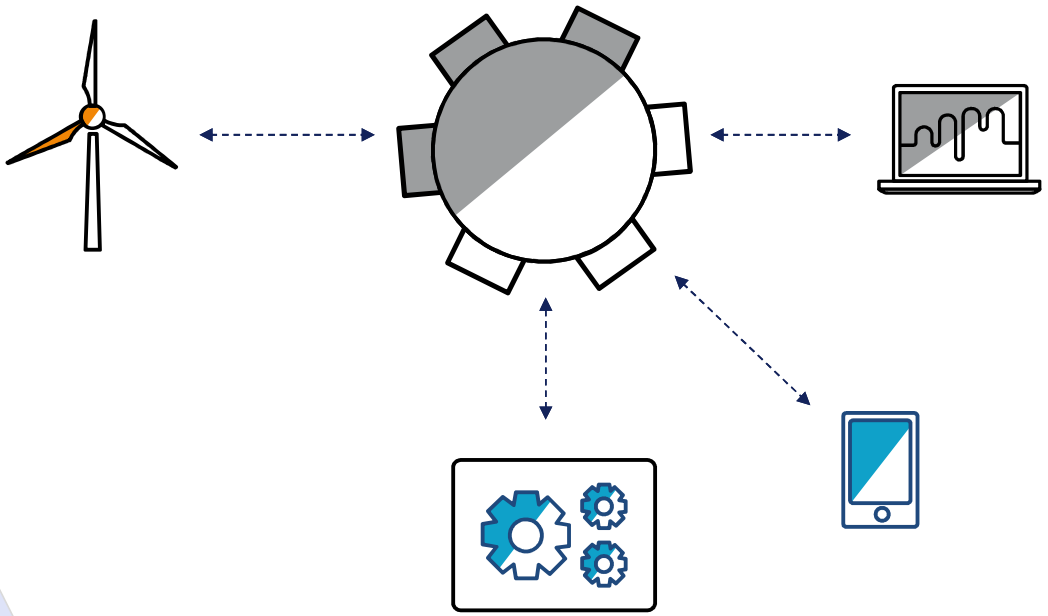
Message Broker

- Scalable, low-latency, reliable message routing based on MQTT protocol
- Two-way message streaming between devices and applications
- Publish/Subscribe for decoupled devices and applications
- Support for QoS0 and QoS1 messaging
- Customizable topic space with support for wildcard topic filters



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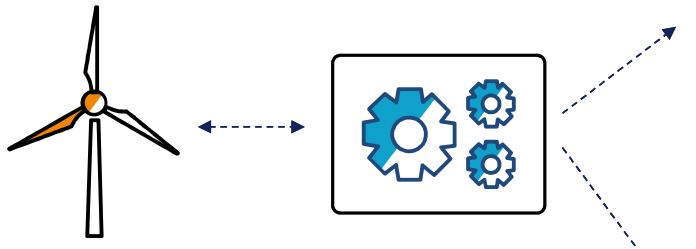
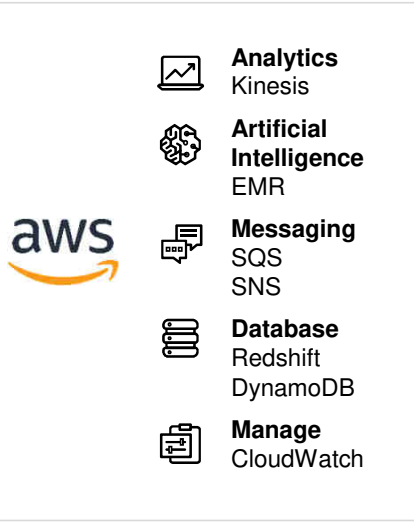
Rules Engine

Data transformation and actions

- Easy to use SQL-like language for transforming, filtering and enriching your data
- Transform—built in functions for math, string manipulation, dates, etc.
- Filter—use the WHERE clause to capture only the data you want
- Enrich—bring in context from the Device Shadow and Amazon Machine Learning or from external sources via inline Lambda execution
- Route—send your data to over 10 AWS services and third party services like Salesforce, HERE, etc.





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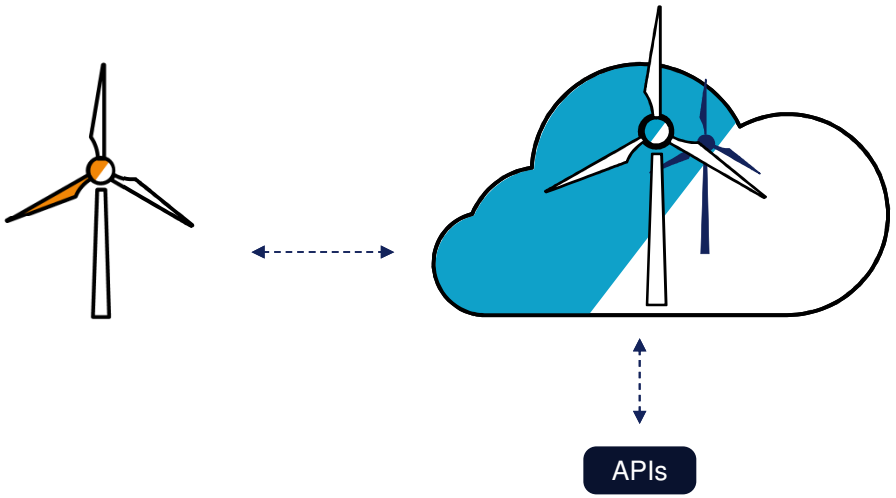
Device Shadow

- Cloud representation of dynamic device state, e.g. temperature or RPM
- Control devices via Shadow updates like volume up or down, on/off etc.
- Devices and application notified of state change in real-time on dedicated MQTT topics (e.g., $aws/things/thing-name/shadow/update/delta)
- Query last known state for offline devices
- Automatic synchronization once devices connect
- REST APIs for applications to discover and interact with devices
- Device SDK integration for easy integration with devices



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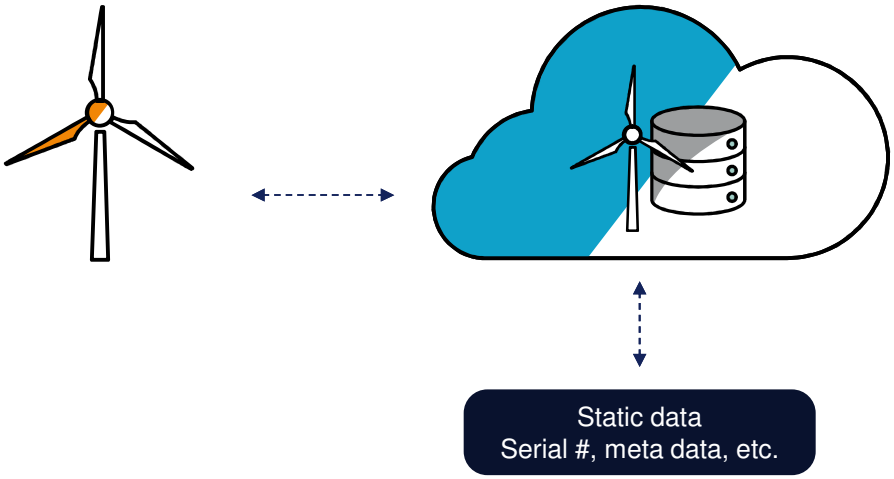
Registry

- Cloud catalog of static device meta data (e.g., Serial number, Manufacturer, etc.)
- Things that share common attributes can be associated with ThingTypes (e.g., LightBulb or Thermostat)
  - Simpler searches
  - Policies can be inherited from associated ThingTypes
- Things can be marshaled into Groups for simpler management (e.g., sensors in one building)



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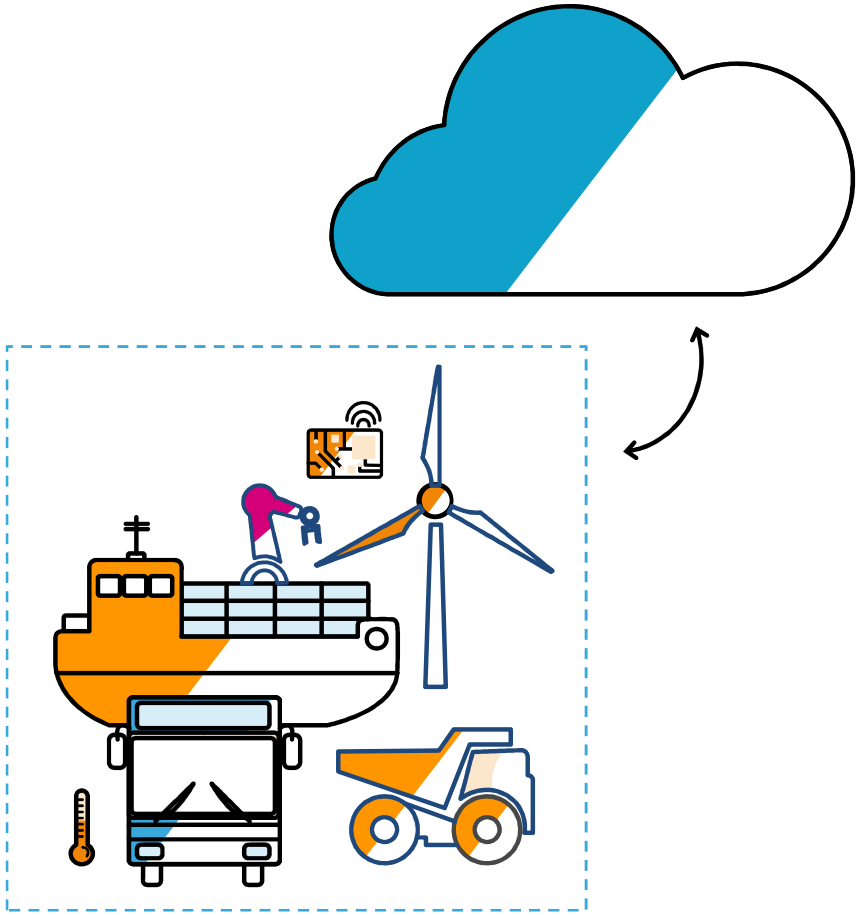
How can I extend AWS cloud capabilities to the edge?



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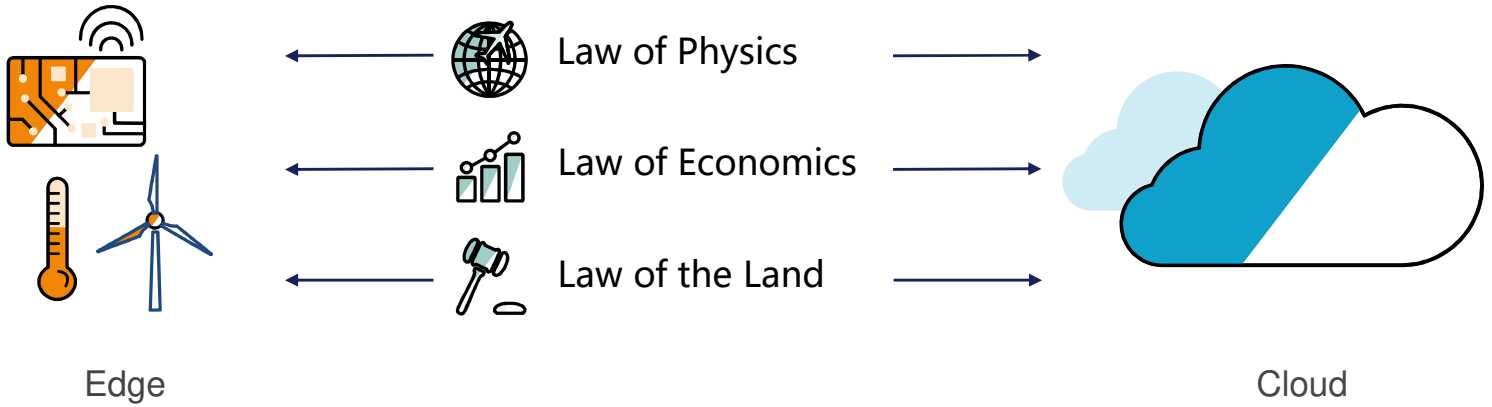
AWS Greengrass

Extend AWS IoT to the Edge

AWS Greengrass extends AWS IoT onto your devices, so that they can act locally on the data they generate, while still taking advantage of the cloud.



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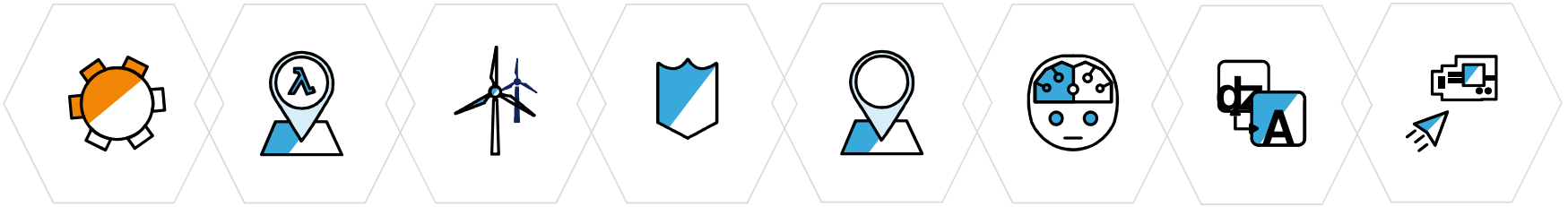
AWS Greengrass

Extend AWS IoT to the Edge



Local Messages and Triggers

Local Message Broker

Local Actions

Lambda Functions

Data and State Sync

Local Device Shadows

Security

AWS-grade security

Local Resource Access

Lambdas Interact With Peripherals

Machine Learning Inference

Local Execution of ML Models

Protocol Adapters

Easy Integrations With Local Protocols

Over the Air Updates

Easily Update Greengrass Core

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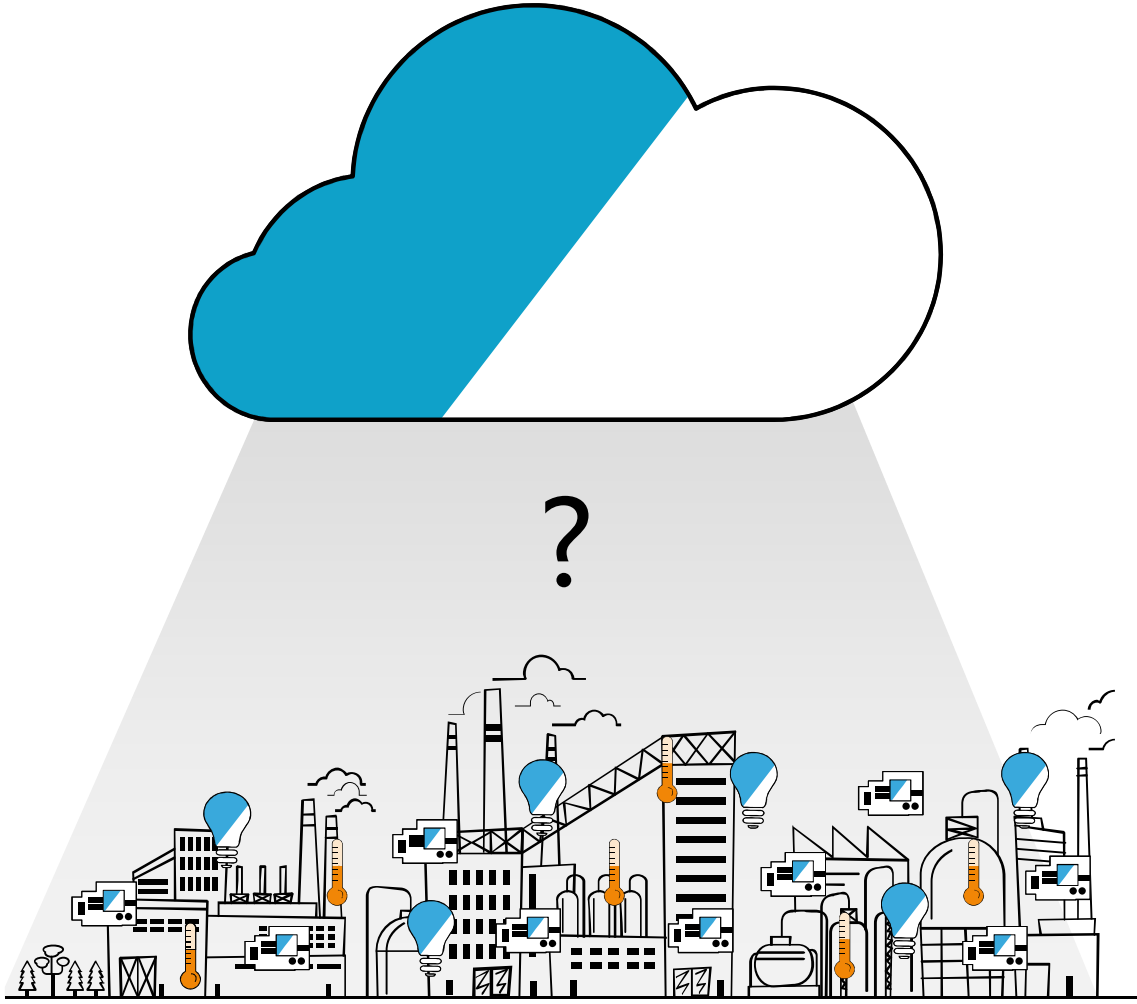
How can I securely connect constrained, microcontroller-based devices?



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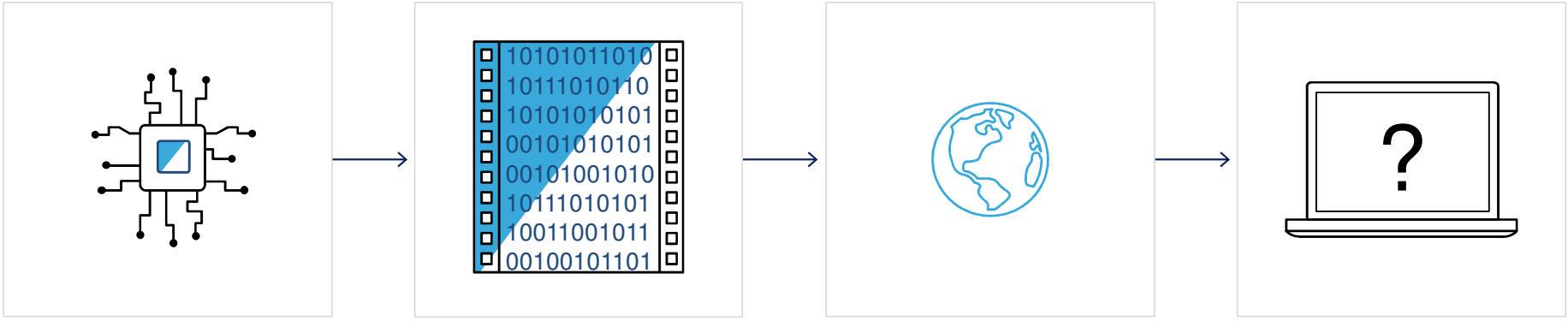
Amazon FreeRTOS

IoT Operating System for Microcontrollers

Amazon FreeRTOS, based on the popular FreeRTOS, is a microcontroller operating system that makes small, low powered edge devices easy to program, deploy, secure, connect, and maintain.



Will it work on my chip?

Does it have the functionality I need?

Where do I get it?

How do I start?

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Amazon FreeRTOS

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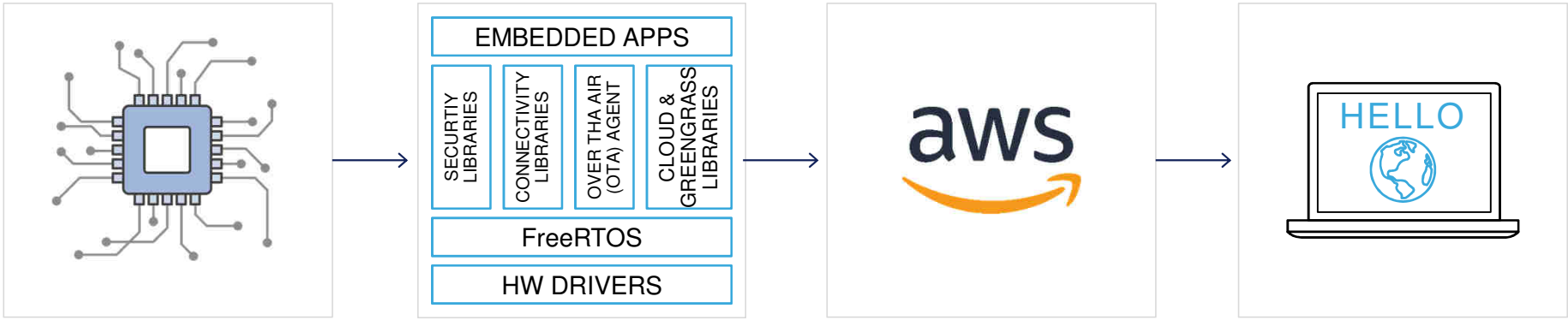

Will it work on my chip?

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How do I start?

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Amazon FreeRTOS

IoT Microcontroller OS

Local Connectivity Libraries

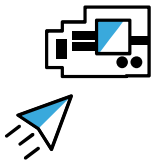
AWS Greengrass

Based on FreeRTOS kernel

Cloud Connectivity Libraries

AWS IoT Core

Security Connectivity Libraries



OTA Beta & Code Signing

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Based on #1 Real-Time Operating System for Microcontrollers

- 15 years, trusted, and widely distributed
- 40+ supported architectures
- Broad ecosystem support
- Free and open source
- Introducing version 10
- MIT Open Source License
- Improved Inter-Process Communication (IPC) capabilities with stream and message buffers

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Local Connectivity Libraries

Connect with AWS Greengrass

- Local communication with edge gateways and a Wi-Fi stack, including AWS Greengrass discovery support
- Wi-Fi management library implements an abstraction layer for Wi-Fi features such as setup, configuration, provisioning, security, and power management
- Continue communicating, collecting data, and taking actions without a cloud connection
- Support for many network topologies and use cases

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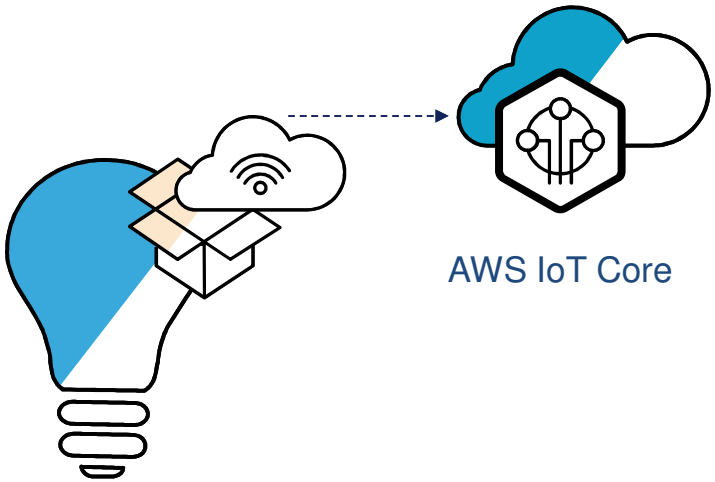
Cloud Connectivity Libraries

- Connectivity to AWS IoT Core
- MQTT Pub/Sub messaging
- Device Shadow support
- Take advantage of IoT Core benefits like IoT Device Management, scalable architecture, and pay as you go pricing
- Fastest way to get started on IoT microcontrollers



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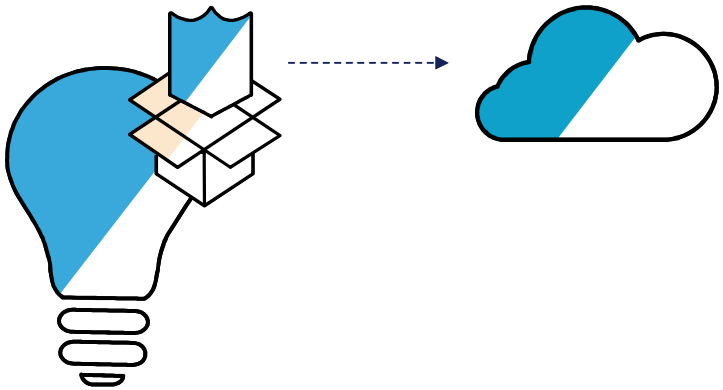
Security Connectivity Libraries

- Secure sockets using TLS
- Certificate-based authentication
- PKCS#11 interface for key management
- Secure by default
- No open network ports
- Only run trusted code
- Clear, modular implementation



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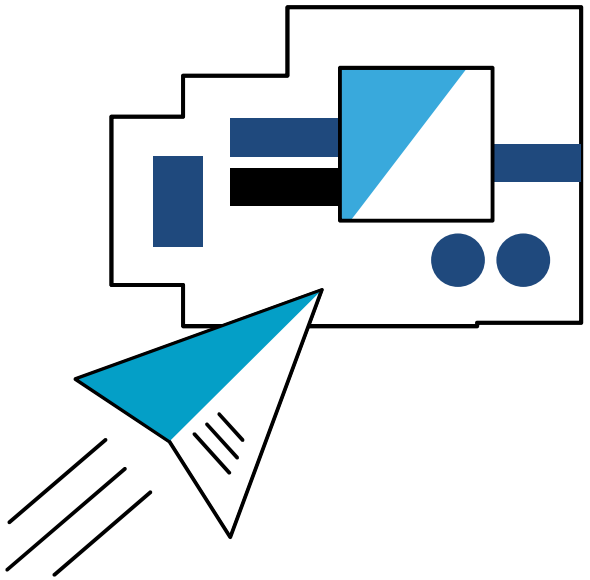
Over-the-Air Firmware Updates

- Use AWS IoT Device Management to assign updates to groups
- Code sign new firmware images
- Stream updates to your device over MQTT
- Validate signature on device
- APIs to control installation and reboot logic
- Simple to manage groups
- Control authorship and ensure devices only run trusted code
- Memory efficient updated client



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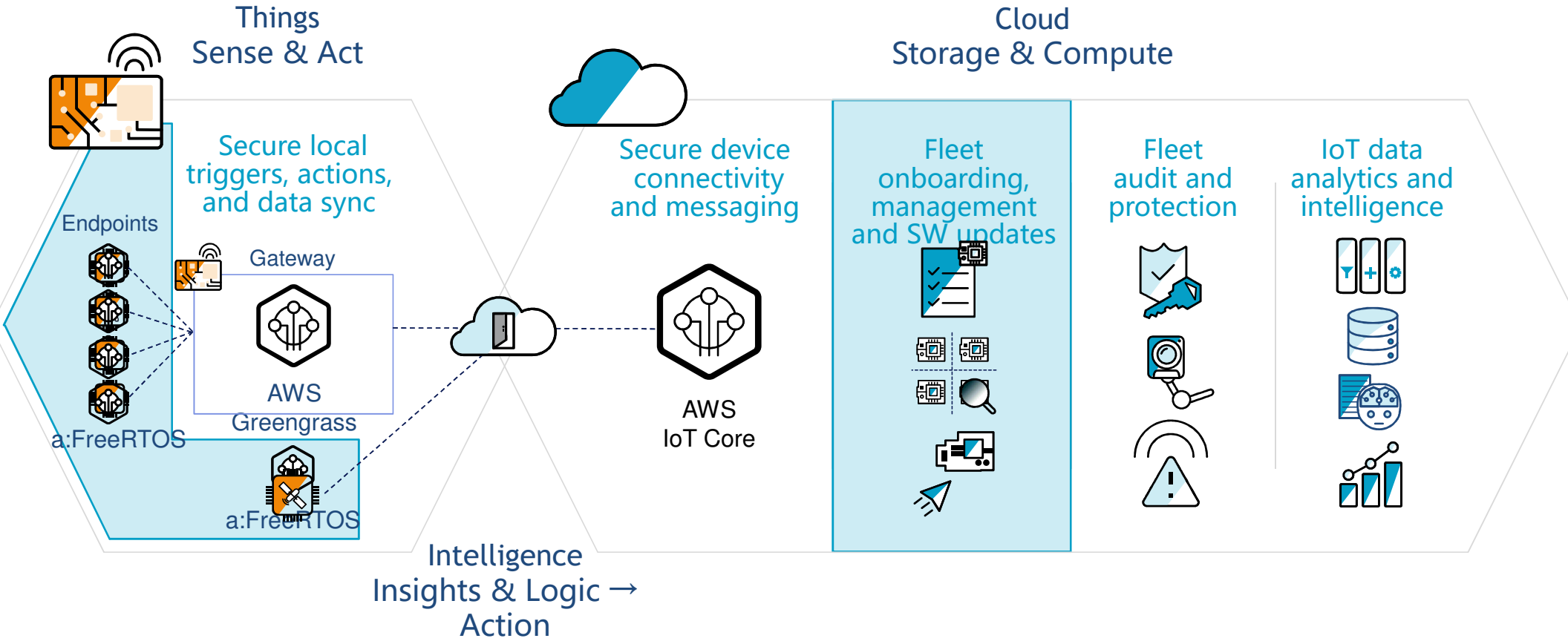
AWS IoT Architecture



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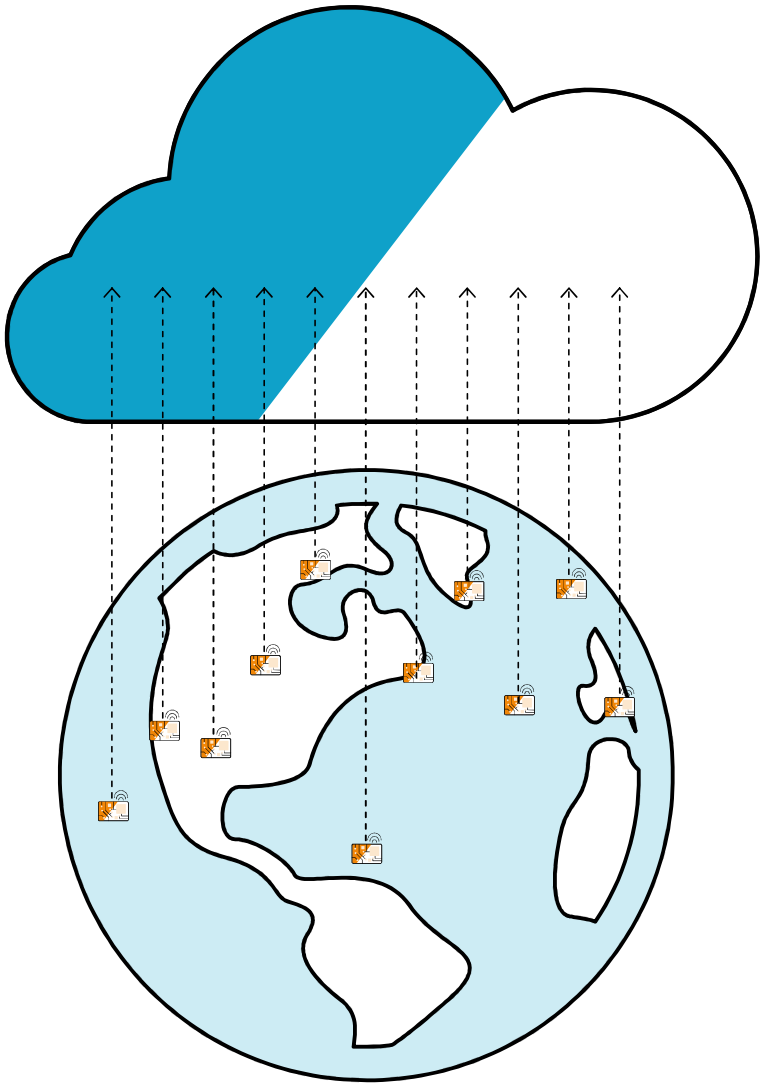
How can I manage my growing number of connected devices?



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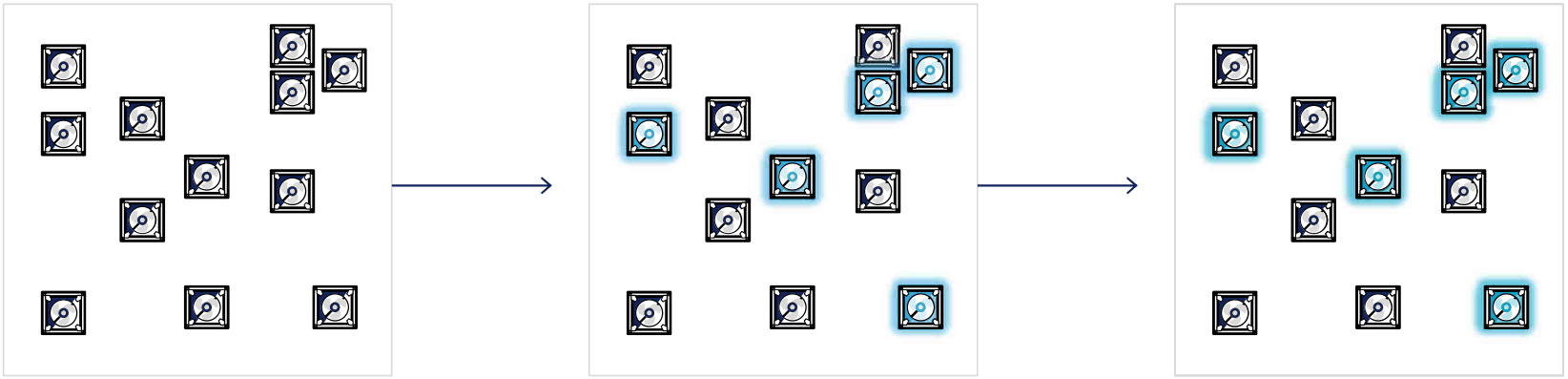
AWS IoT Device Management

Device Management Service

AWS IoT Device Management helps you onboard, organize, monitor, and remotely manage your growing number of connected devices.



Fast device onboarding at scale

Real-time fleet indexing and search

Monitoring and updating devices

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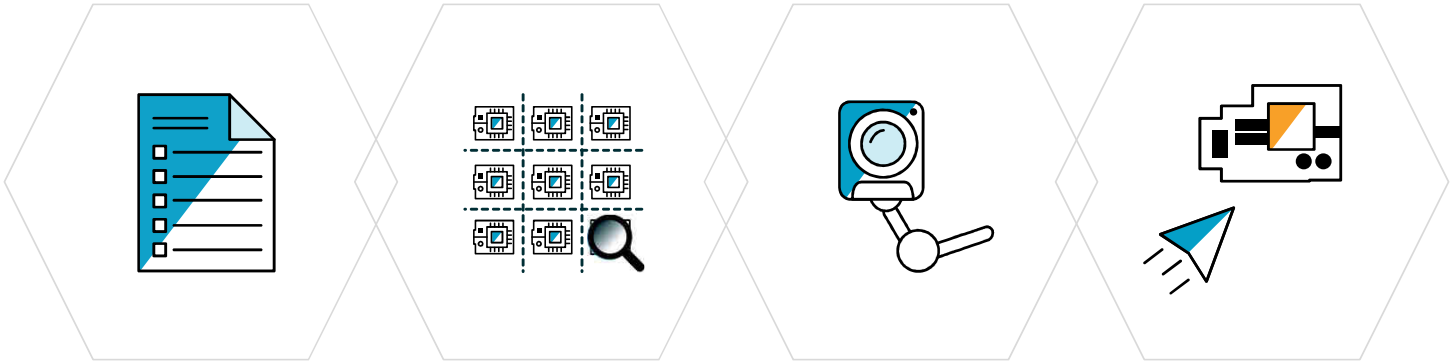
AWS IoT Device Management

Maintain Fleet Health



Batch Fleet Provisioning

Real-time Fleet Index & Search

Fine Grained Device Logging & Monitoring

Over the Air Updates

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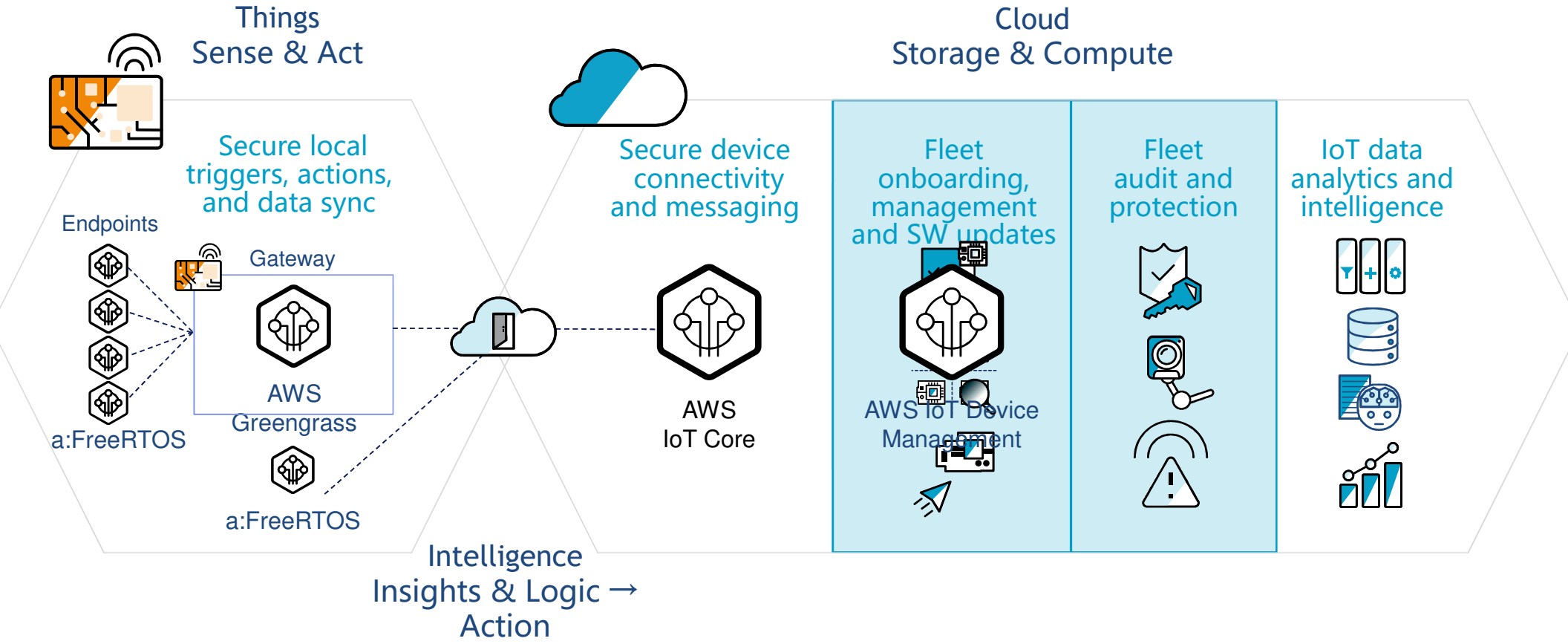
AWS IoT Architecture



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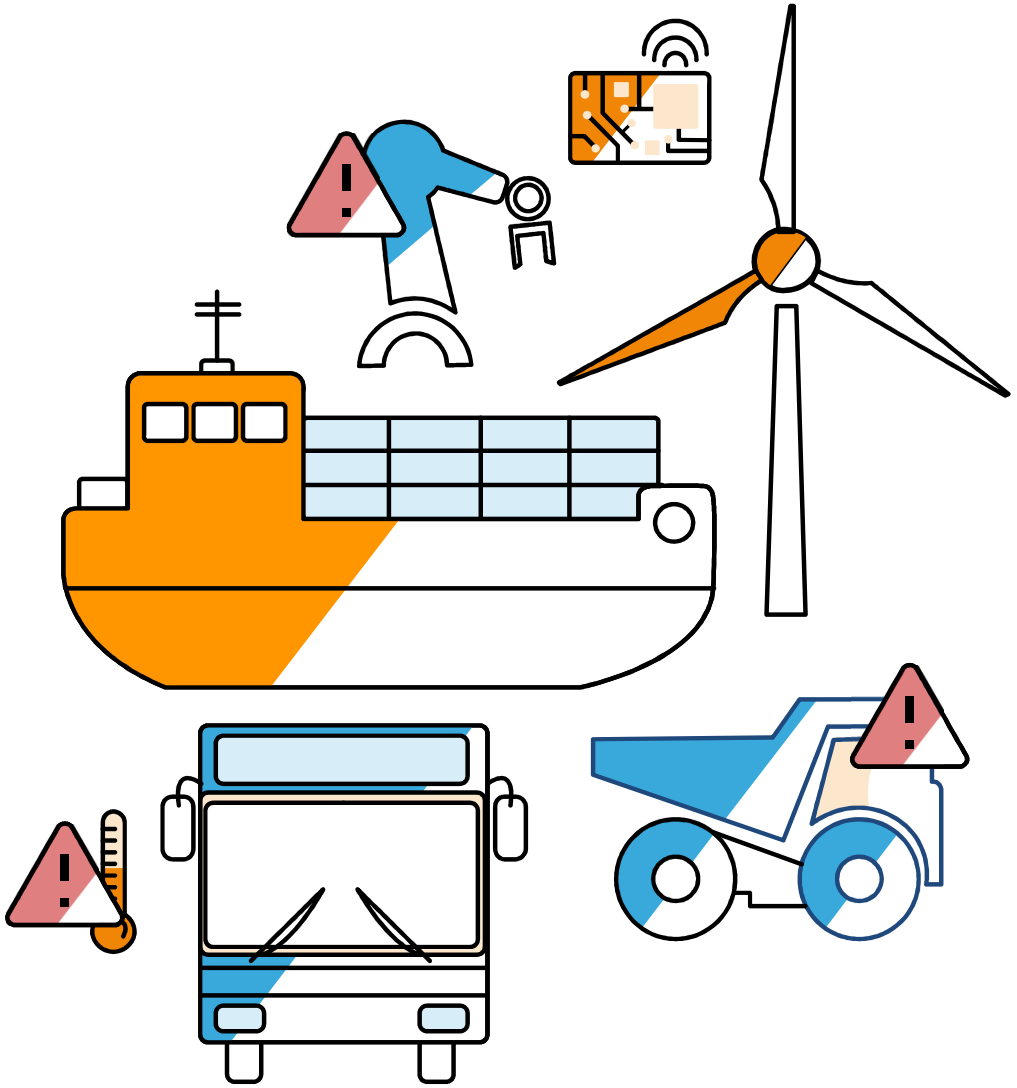
How do I ensure my connected devices stay secure?



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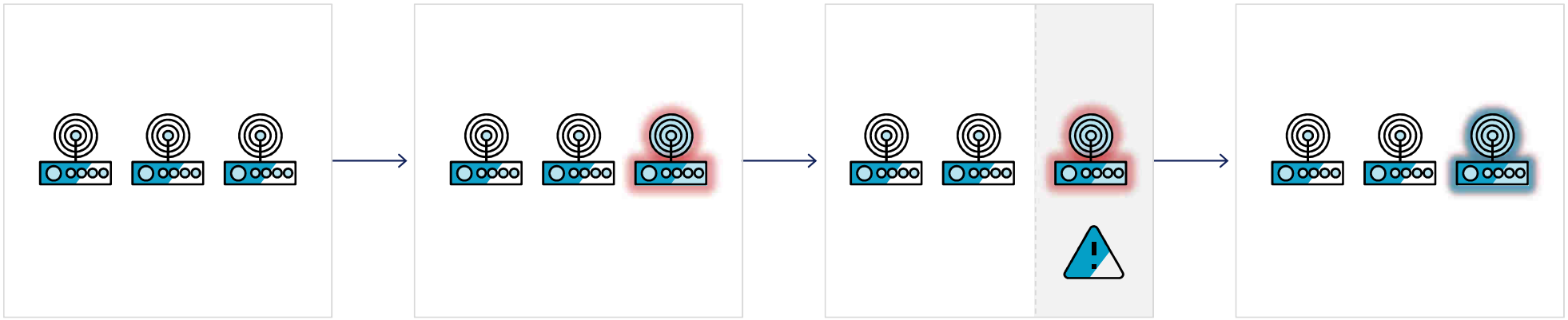
AWS IoT Device Defender

Keep Your Fleet Secure

AWS IoT Device Defender is a fully managed IoT security service that enables you to secure your fleet of connected devices on an ongoing basis.



Audit device configurations, define and monitor device behavior

Identify drifts in security settings and detect device anomalies

Generate alerts

Patch security vulnerabilities

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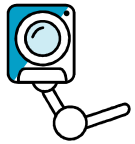
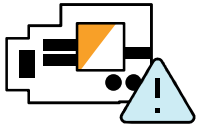
AWS IoT Device Defender

Keep Your Fleet Secure

Audit Device Configurations



Monitor Device Behavior



Identify Anomalies

Generate Alerts

Patch Security Vulnerabilities

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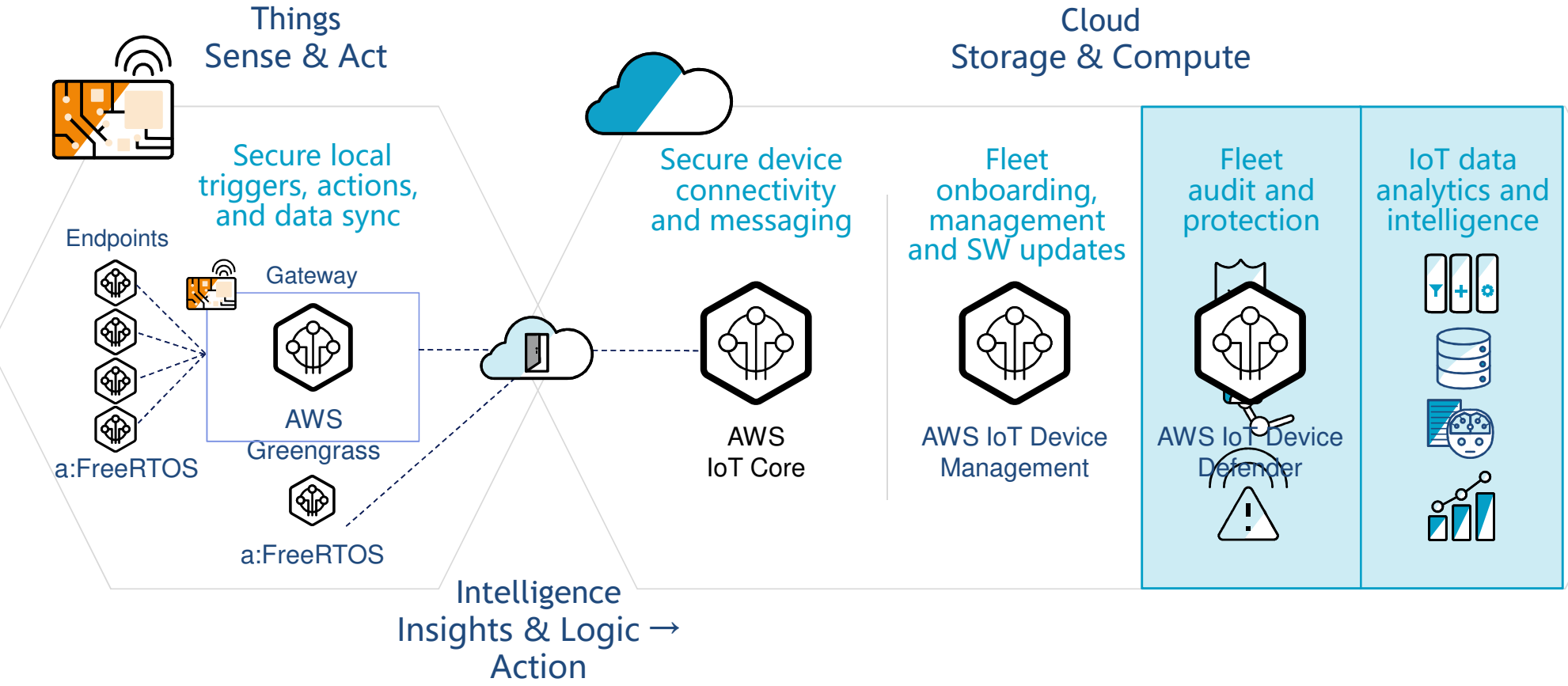
AWS IoT Architecture



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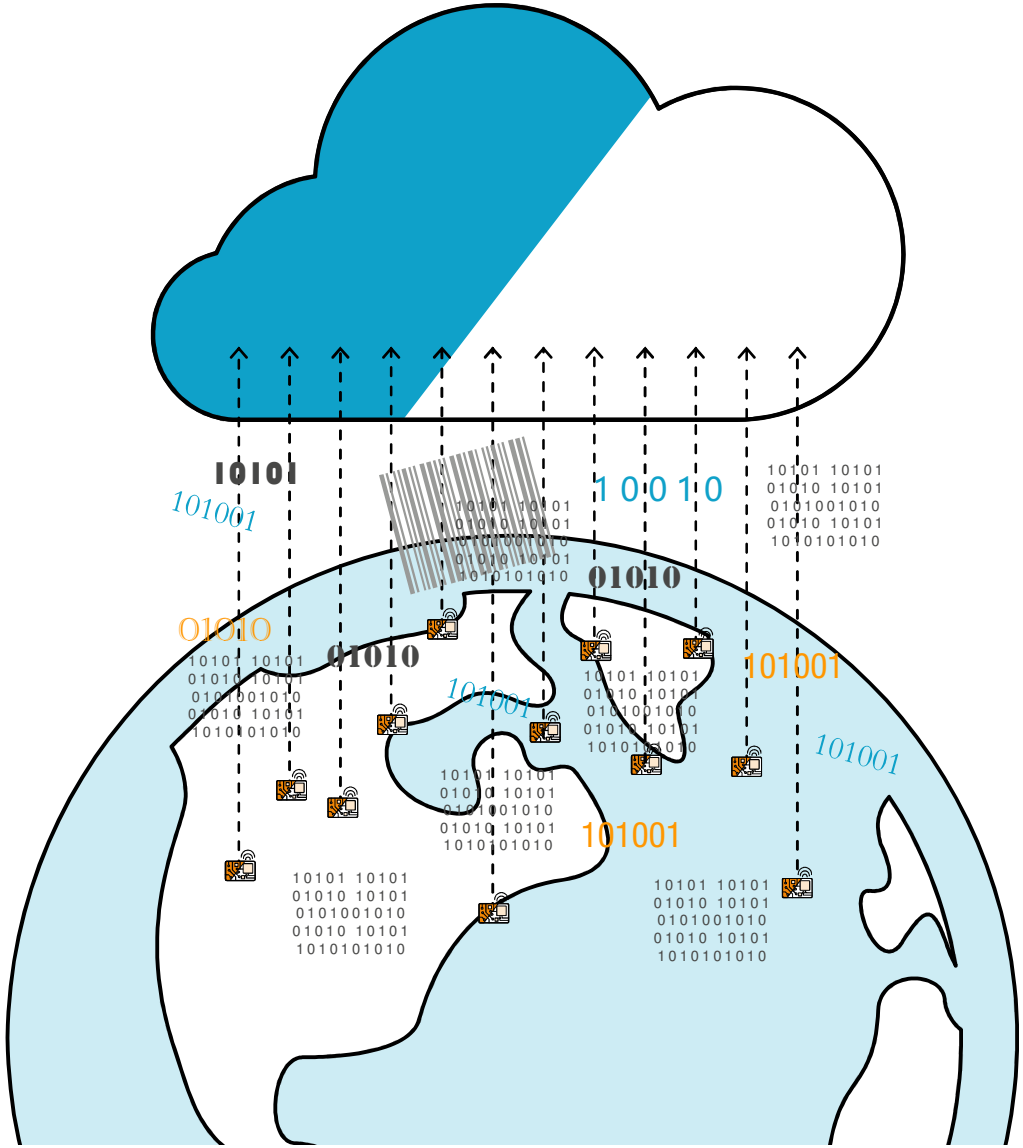
How do I generate value from my device data?



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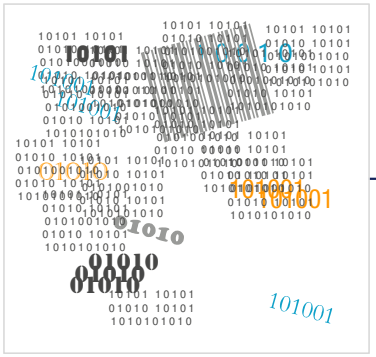
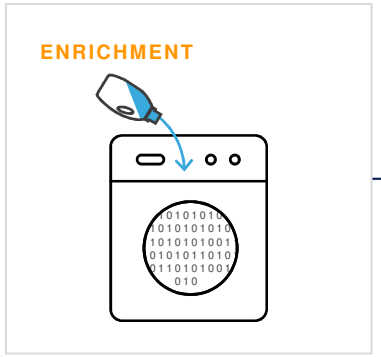
AWS IoT Analytics

Analytics for IoT Devices

AWS IoT Analytics is a service that processes, enriches, stores, analyzes, and visualizes IoT data for manufacturers and enterprises.



IoT data is noisy and contains gaps and false readings



Filter, process, transform, and enrich your data

Store raw data and processed data

Ad-hoc queries or sophisticated IoT analytics and visualization

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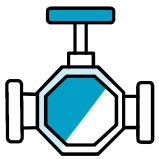
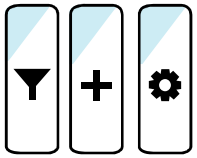
AWS IoT Analytics

Easily analyze IoT data

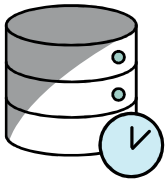
AWS IoT Analytics is a service that processes, enriches, stores, analyzes, and visualizes IoT data for manufacturers and enterprises.



Channels

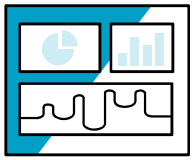


Pipelines



Data Stores

Datasets



Jupyter Notebooks & Templates

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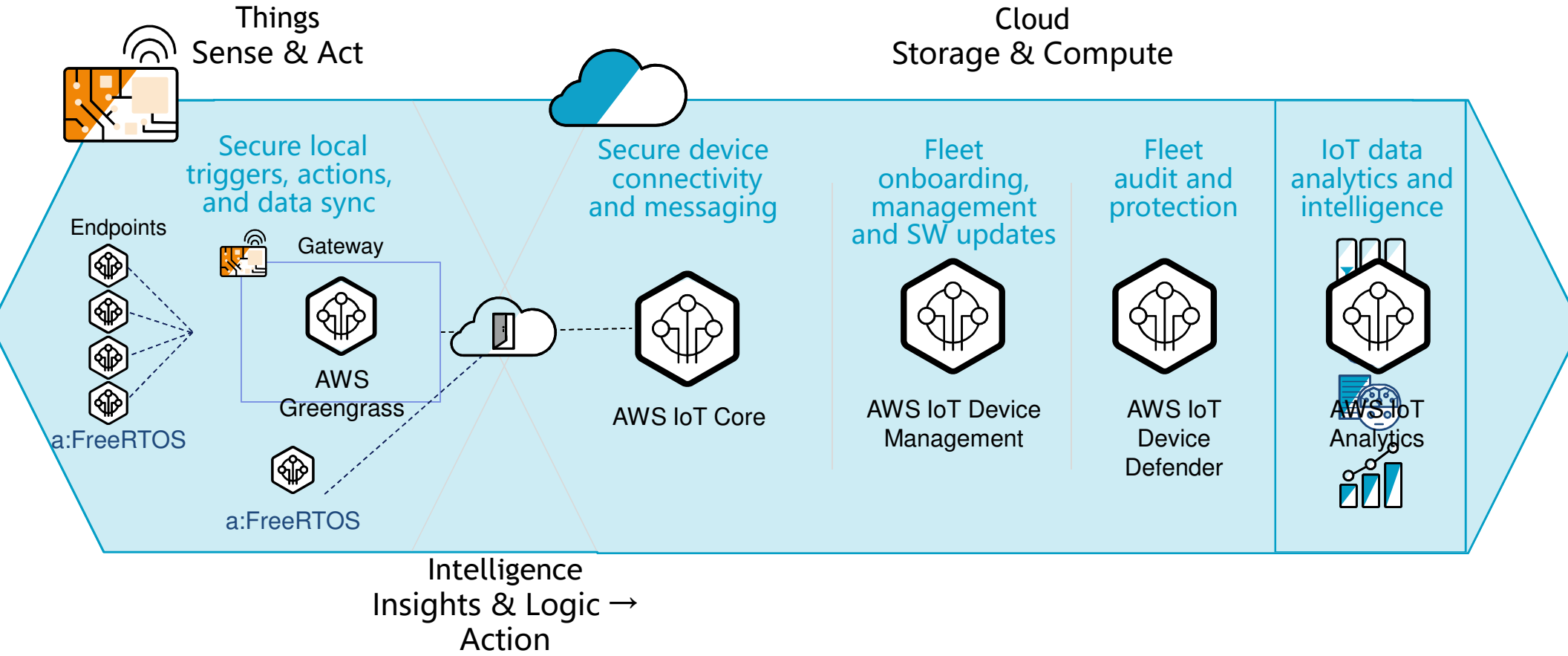
AWS IoT Architecture



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Amazon FreeRTOS Device Software

- NOTE: the training as given during the Technology Tour session requires temporary access to specific accounts. Generic instructions on how to get started with ST's Discovery Kit IoT Node and Amazon FreeRTOS can be found here
  - https://console.aws.amazon.com/iot/home?#/software/freertos
  - https://docs.aws.amazon.com/freertos/latest/userguide/getting_started_st.html

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