

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

AME Marketing



Technology Tour 2019

Anaheim, CA | March 26



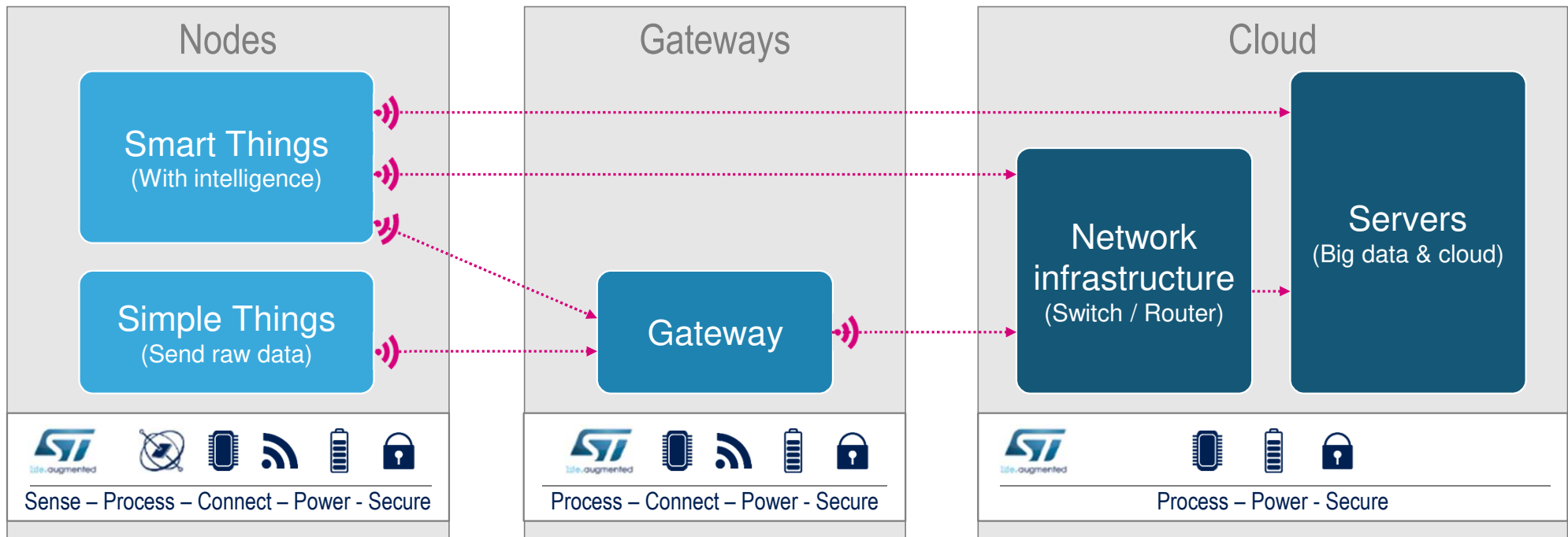


The IoT Movement

2

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



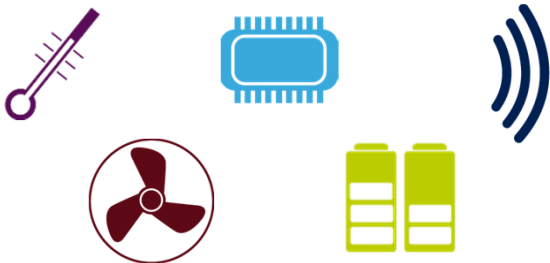
ST Has all the Building Blocks for the IoT

3



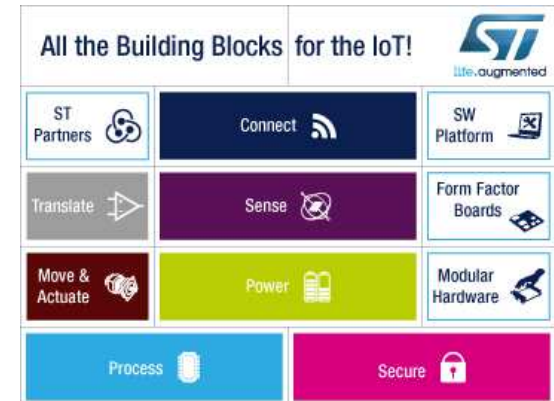
“Thing” you know how to build.

Plus what “Smart”?



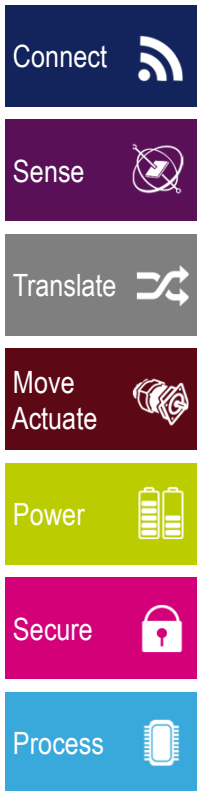
Pieces from different sources and
and no building instructions...

...or



Supporting the IoT Movement

4



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



Development environments



Debug solutions



Simulation and analysis tools



On-line design tools





STM32L475 Discovery Kit IoT Node

B-L475E-IOT01A

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SW Libraries for STM32L4 MCU & Sensors

Low-power long-range communication (SubGHz)

Direct Wi-Fi connection to cloud servers

Environmental awareness: humidity, pressure, temp

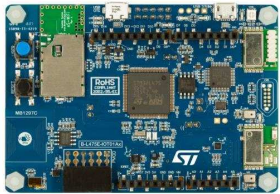
Detection hub: motion, proximity, audio



Workshop Deliverables

6

- 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-1475e-iot01a.html

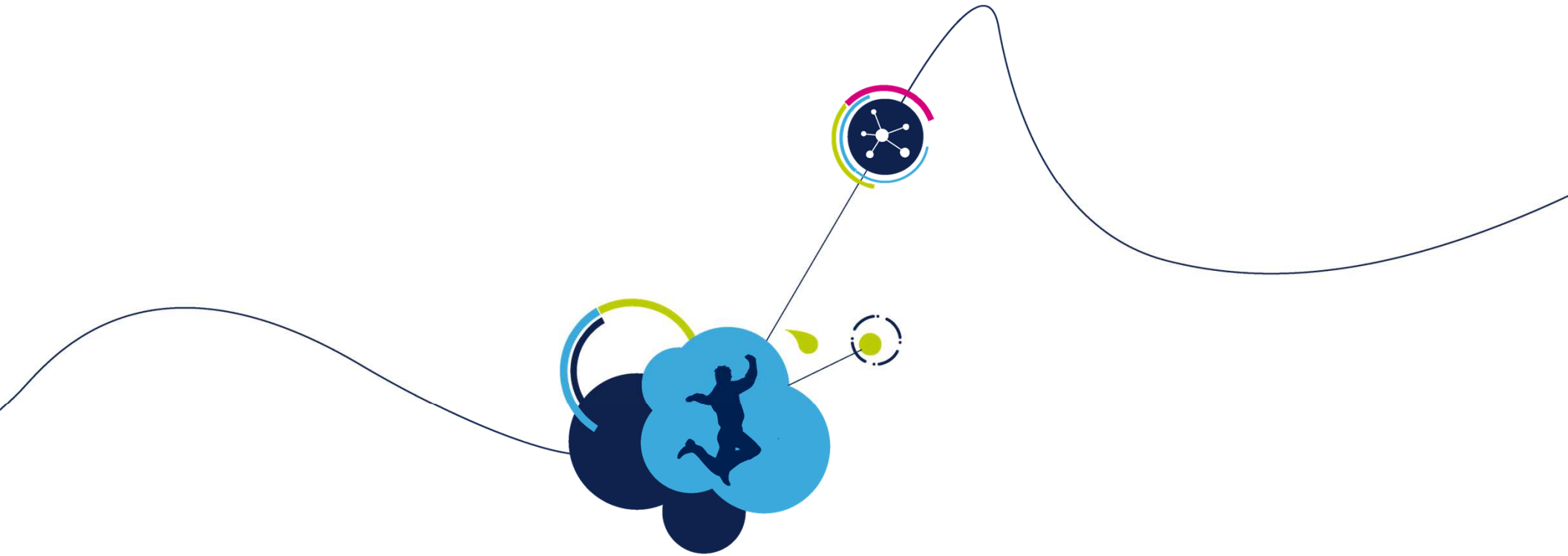


USB 2.0 A-Male to Micro B Cable

STM32L4 Discovery Kit IoT Node

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- 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.



Software and Other Pre-requisites



Software and Others Pre-requisites

Windows (Win7, Win8, Win10)

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- **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)

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<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”



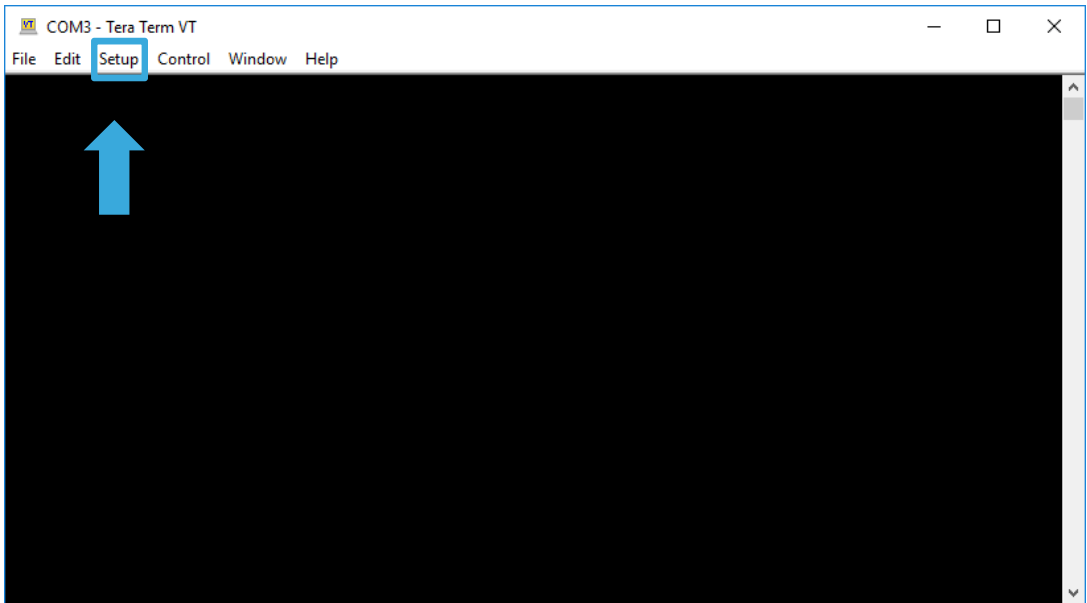
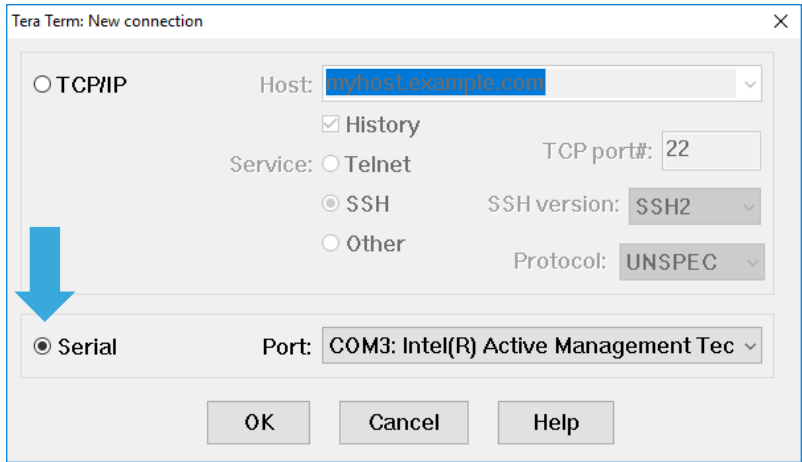
- `install_sw4stm32_linux_64bits-latest.run`

- 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)`



Tera Term Setup

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Tera Term Setup

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Tera Term: Serial port setup

Port: COM3

Speed: 115200

Data: 8 bit

Parity: none

Stop bits: 1 bit

Flow control: none

Transmit delay: 0 msec/char 0 msec/line

OK Cancel Help

Tera Term: Terminal setup

Terminal size: 80 x 25

☒ Term size = win size

☐ Auto window resize

Terminal ID: VT100

Answerback:

Coding (receive): UTF-8

locale: american

New-line: Receive: LF Transmit: CR+LF

☒ Local echo

☐ Auto switch (VT<->TEK)

Coding (transmit): UTF-8

CodePage: 65001

OK Cancel Help



Software and Others Pre-requisites

Mac OS: PicoCom

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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`



Software and Others Pre-requisites

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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
```

usb device name

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

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)

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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`

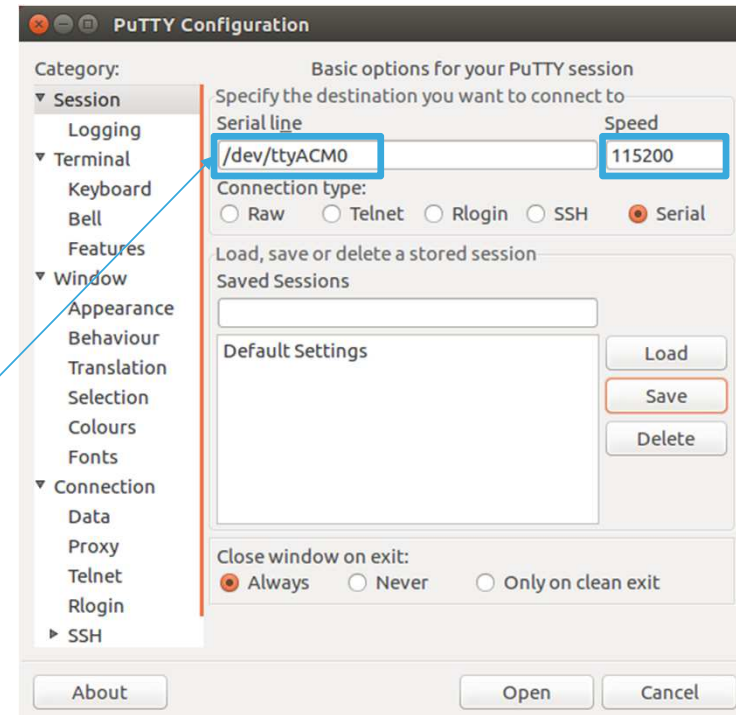


Open and Configure Serial Terminal (Putty)

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

```
mano@Mano-HP8460p: ~  
[ 1277.173596] sd 6:0:0:0: [sdb] Attached SCSI removable disk  
[ 1295.516620] usb 2-1.2: USB disconnect, device number 7  
[ 1295.553583] blk_partition_remap: fail for partition 1  
[ 1297.017230] usb 2-1.2: new full-speed USB device number 8 using ehci-pci  
[ 1297.128516] usb 2-1.2: New USB device found, idVendor=0483, idProduct=374b  
[ 1297.128524] usb 2-1.2: New USB device strings: Mfr=1, Product=2, SerialNumber  
=3  
[ 1297.128529] usb 2-1.2: Product: STM32 STLink  
[ 1297.128533] usb 2-1.2: Manufacturer: STMicroelectronics  
[ 1297.128538] usb 2-1.2: SerialNumber: 066FFF484851877267045729  
[ 1297.388141] usb-storage 2-1.2:1.1: USB Mass Storage device detected  
[ 1297.388461] scsi host6: usb-storage 2-1.2:1.1  
[ 1297.389062] cdc_acm 2-1.2:1.2: ttyACM0: USB ACM device  
[ 1298.406662] scsi 6:0:0:0: Direct-Access M0BD Microcontroller 1.0 PQ  
: 0 ANSI: 2  
[ 1298.407553] sd 6:0:0:0: Attached scsi generic sg2 type 0  
[ 1298.408136] sd 6:0:0:0: [sdb] 2120 512-byte logical blocks: (1.09 MB/1.04 MiB  
)  
[ 1298.408851] sd 6:0:0:0: [sdb] Write Protect is off  
[ 1298.408857] sd 6:0:0:0: [sdb] Mode Sense: 03 00 00 00  
[ 1298.409738] sd 6:0:0:0: [sdb] No Caching mode page found  
[ 1298.409749] sd 6:0:0:0: [sdb] Assuming drive cache: write through  
[ 1298.433859] sd 6:0:0:0: [sdb] Attached SCSI removable disk  
mano@Mano-HP8460p:~$
```

Note down device
name for Discovery Kit

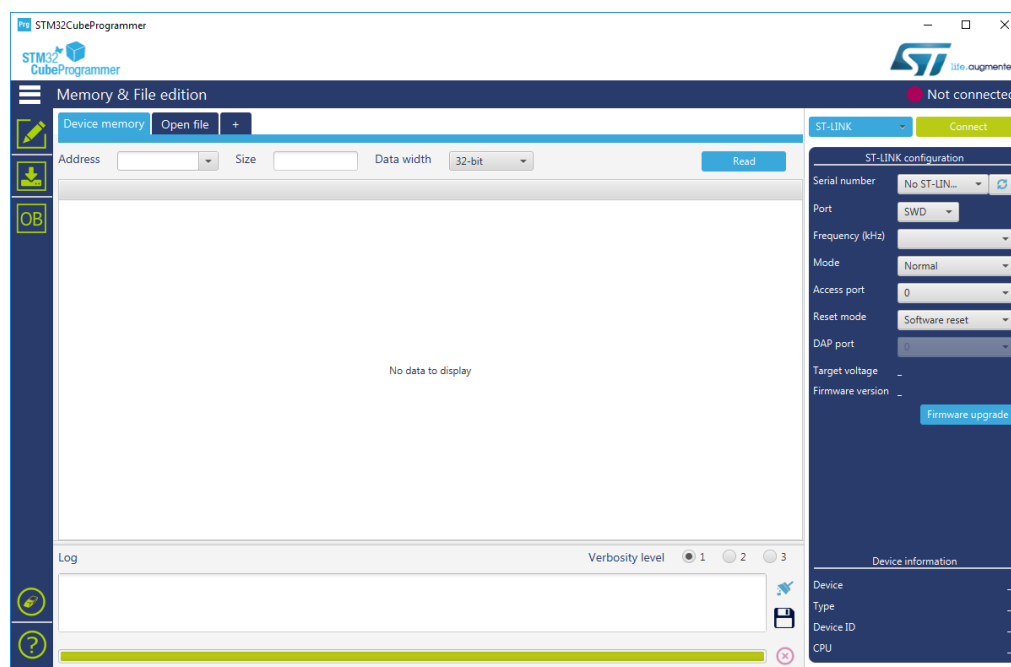


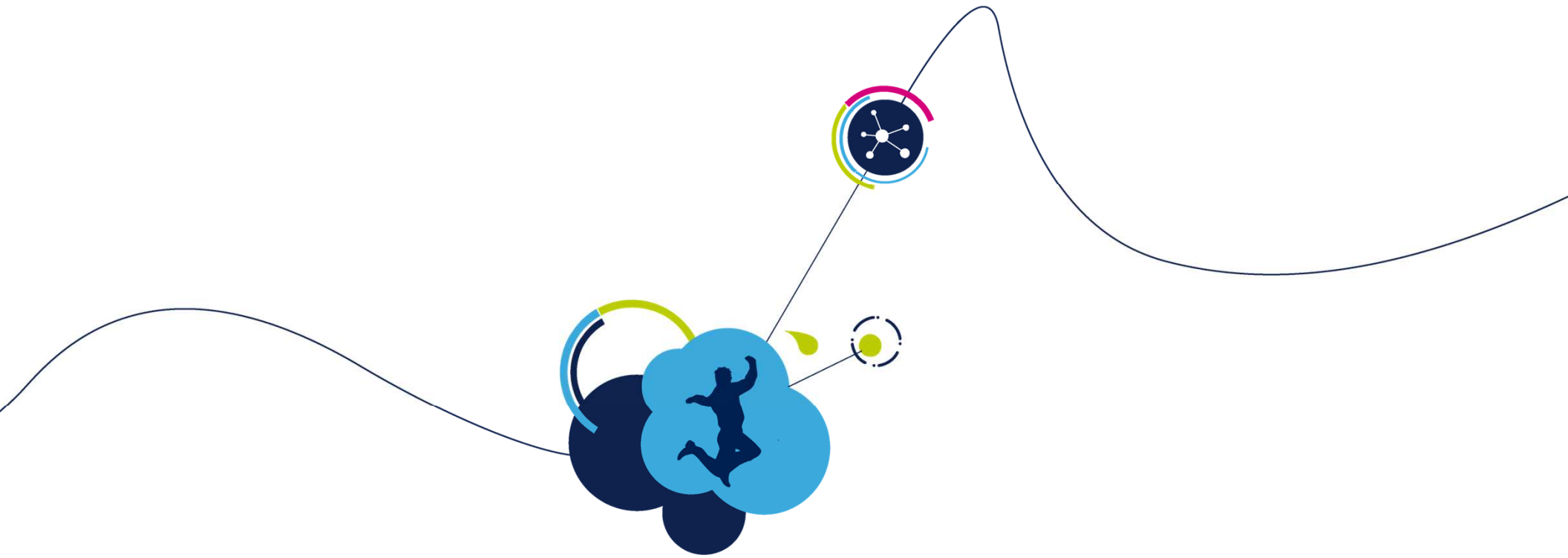


STM32CubeProg

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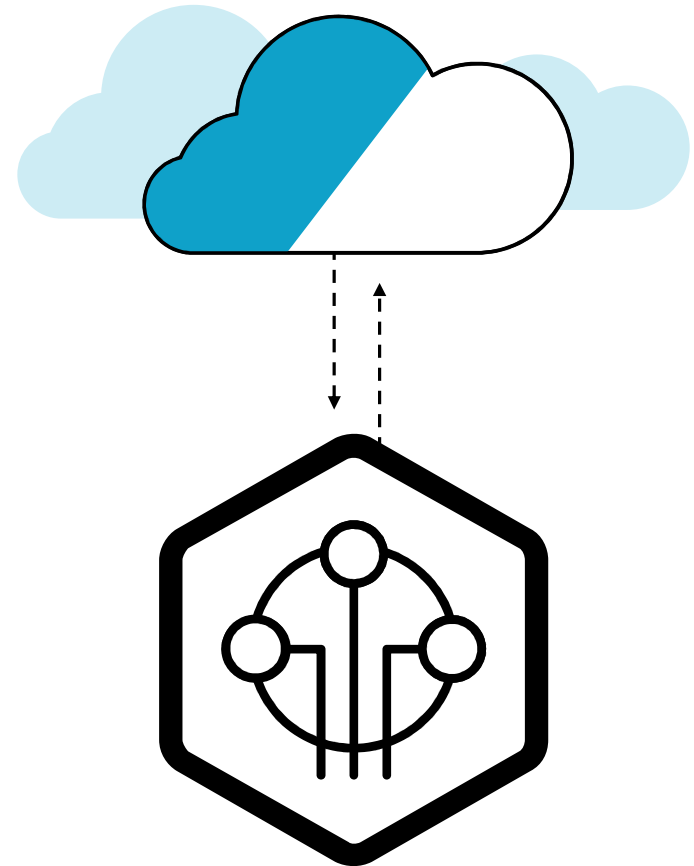
- STM32CubeProgrammer (STM32CubeProg) is an all-in-one multi-OS software tool for programming STM32 products.
- https://www.st.com/content/st_com/en/products/development-tools/software-development-tools/stm32-software-development-tools/stm32-programmers/stm32cubeprog.html





Amazon Web Services

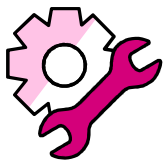
IoT on AWS



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

what problems would you solve?

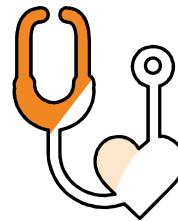
What customers are doing with AWS IoT



Predictive maintenance



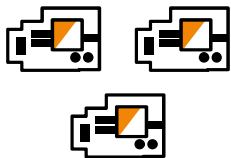
Wellness & health solutions



Remote patient monitor



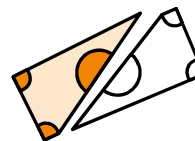
Connected buildings & city systems



Maintain device fleets



Monitor energy efficiency



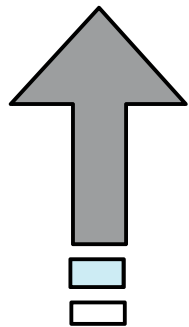
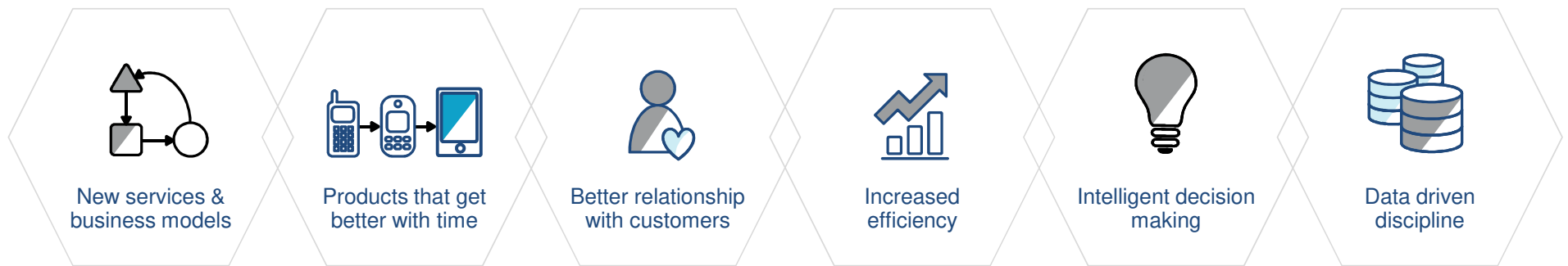
IoT payment & connected commerce



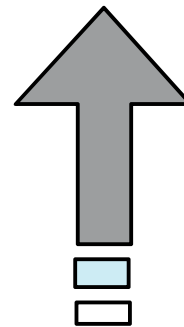
Safeguard manufacturing facilities

Nobody just buys IoT
technology...
they seek business outcomes

Business outcomes with IoT

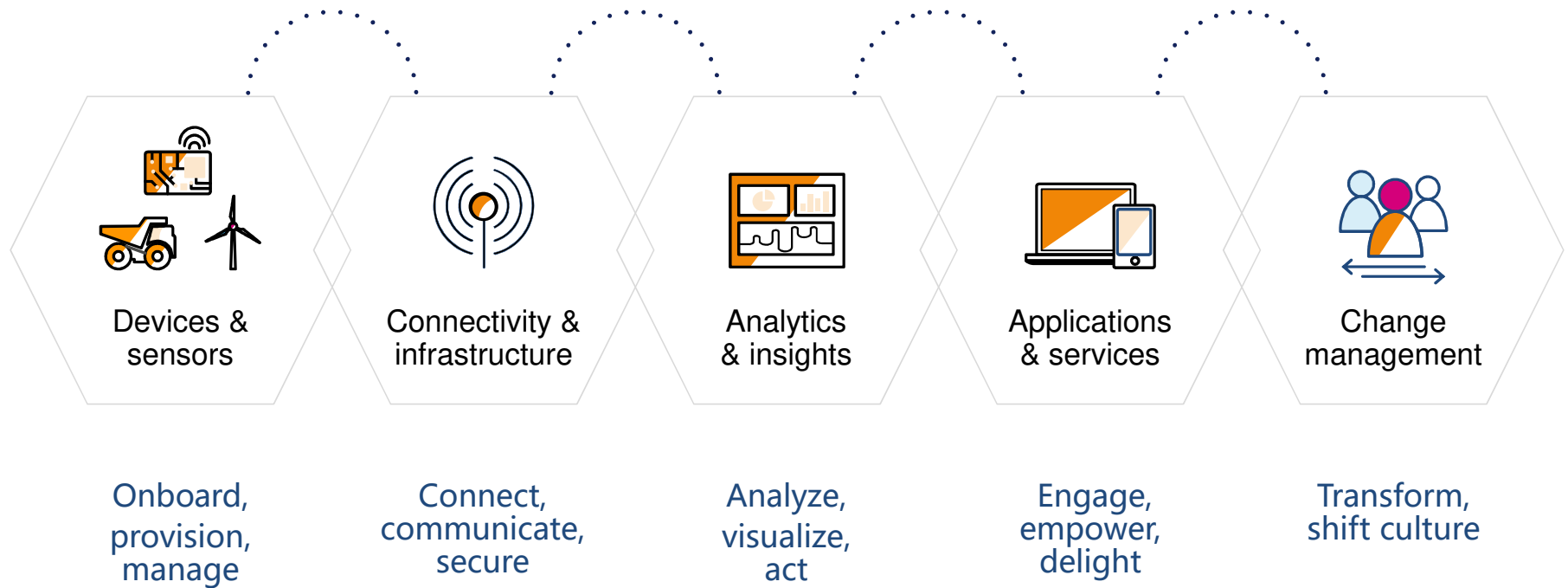


Revenue growth
IoT data drives business growth

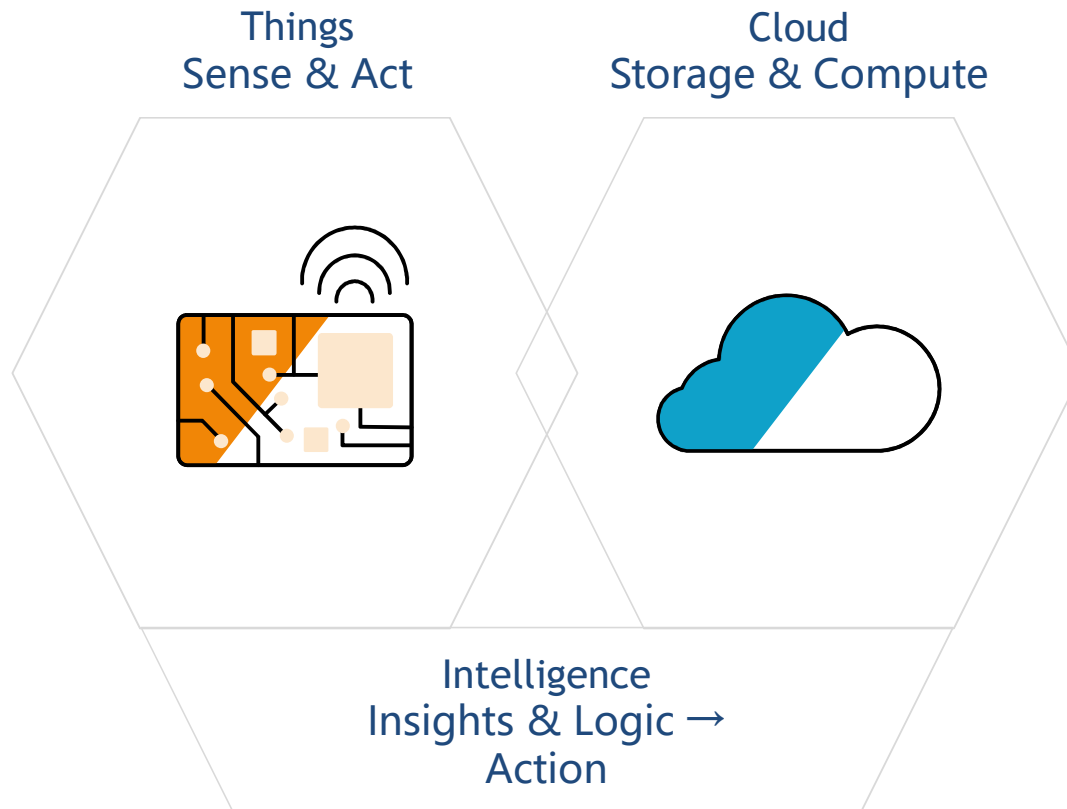


Operational efficiency
IoT data decreases OpEx

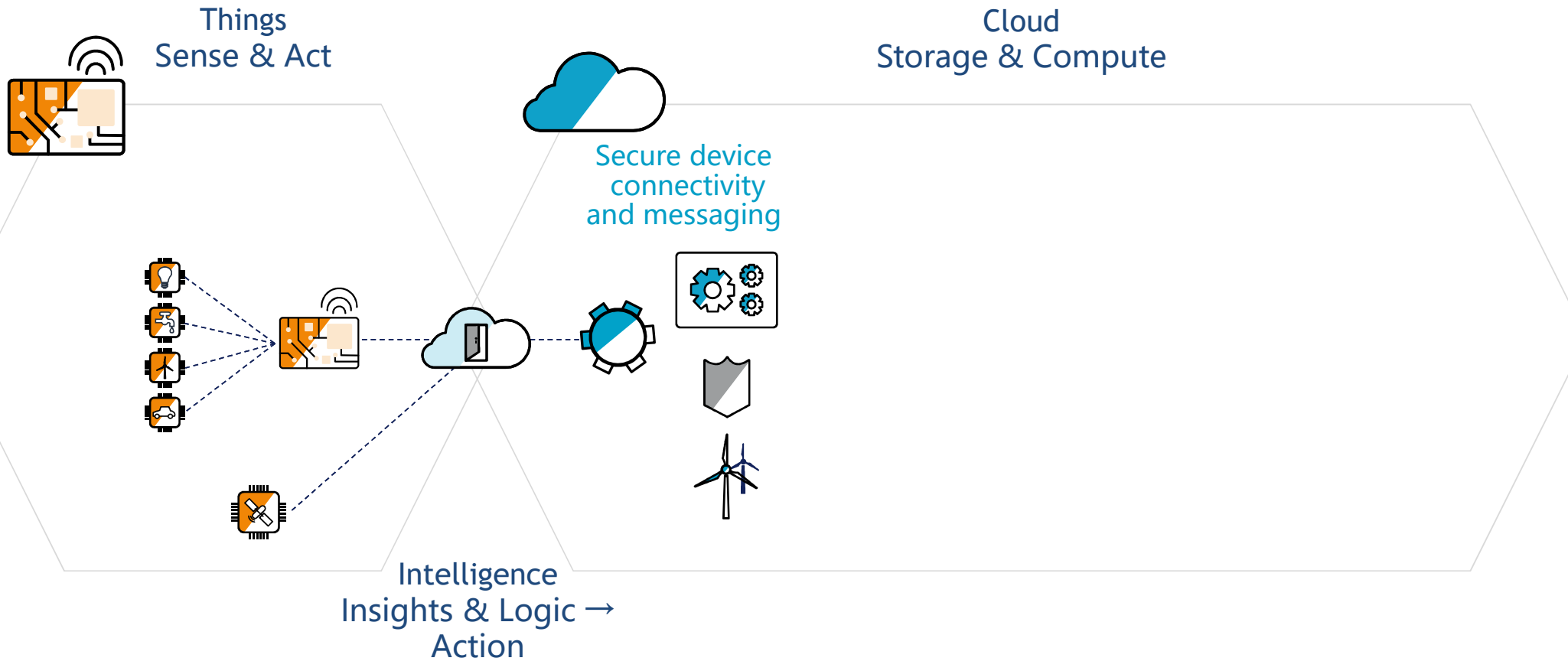
IoT solutions are complex & multidimensional



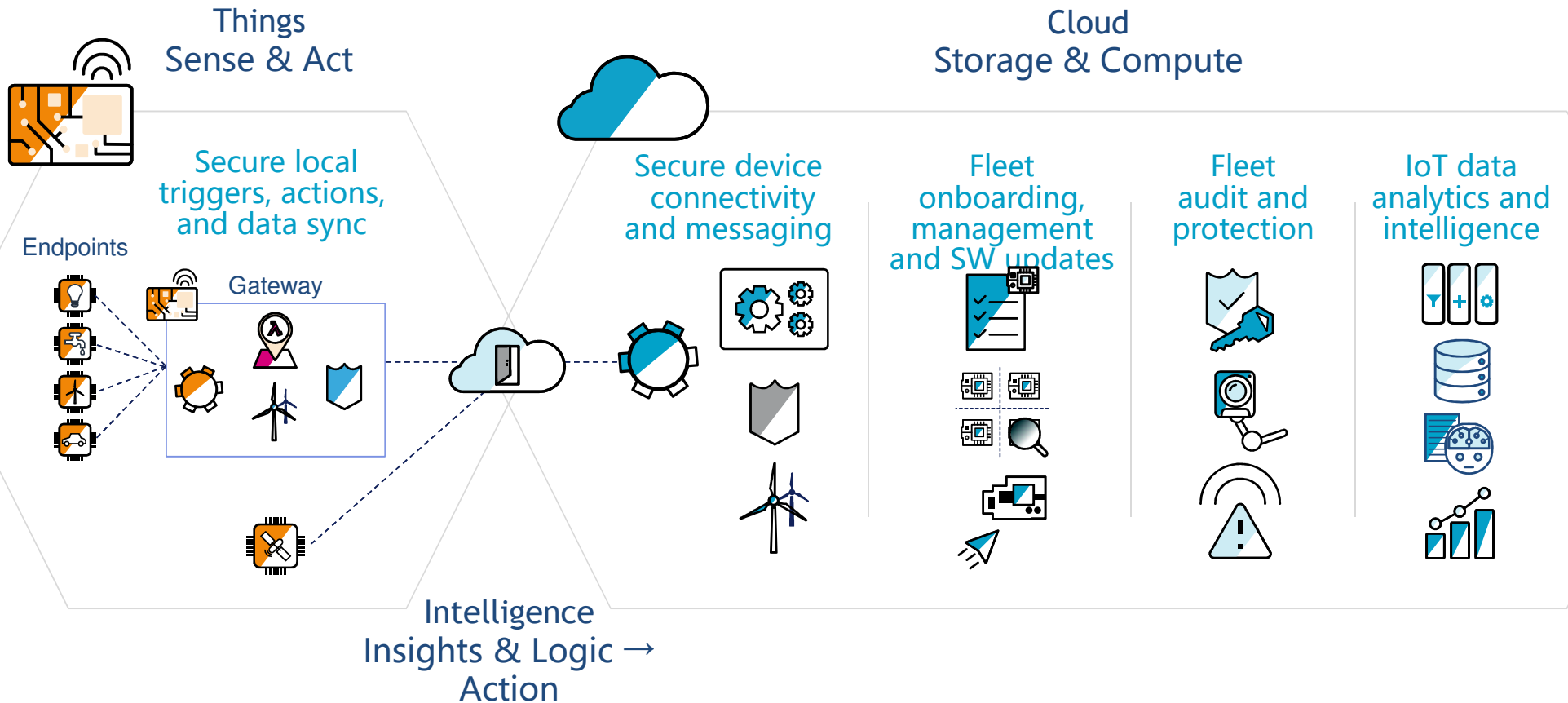
Our concept of IoT



AWS IoT Architecture

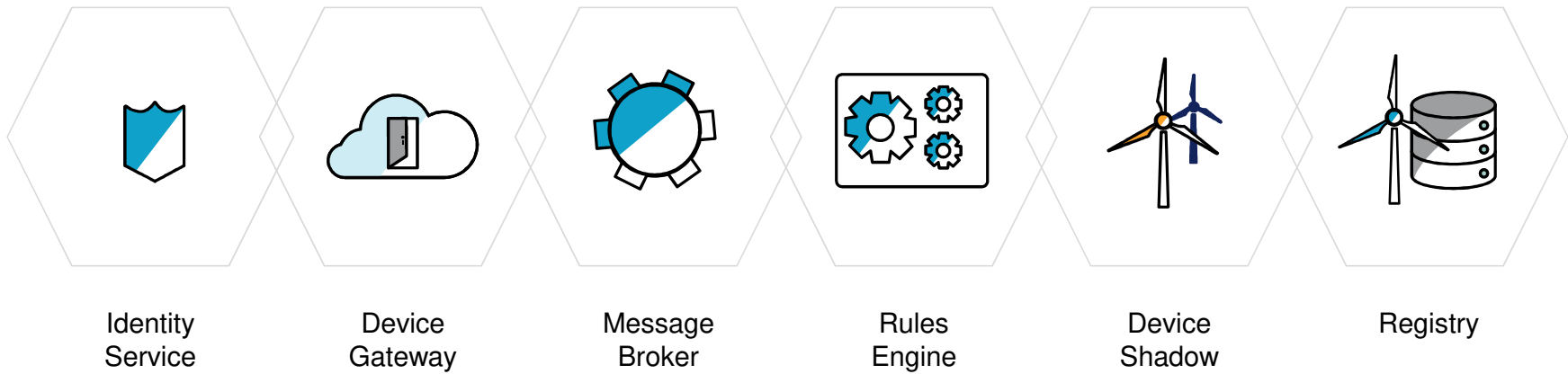


AWS IoT Architecture



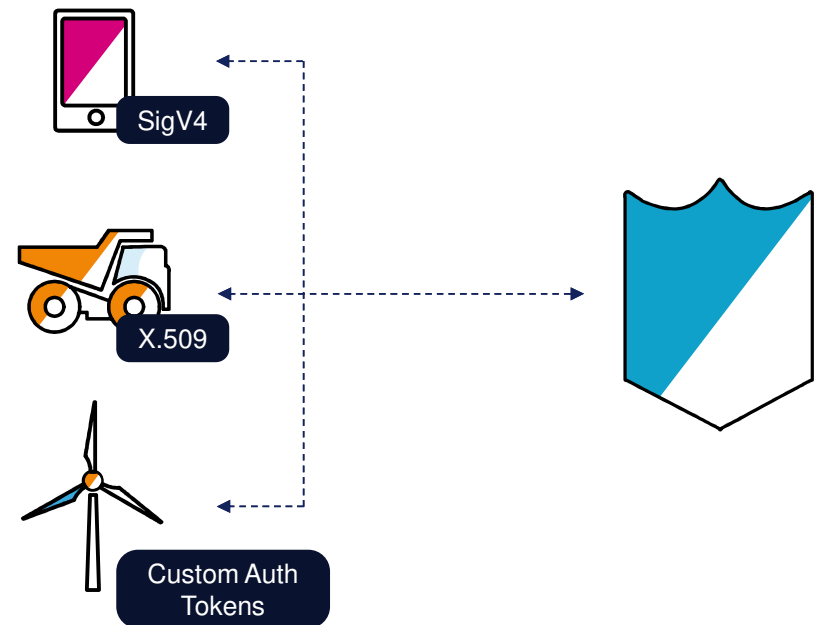


Secure Device Connectivity and Messaging



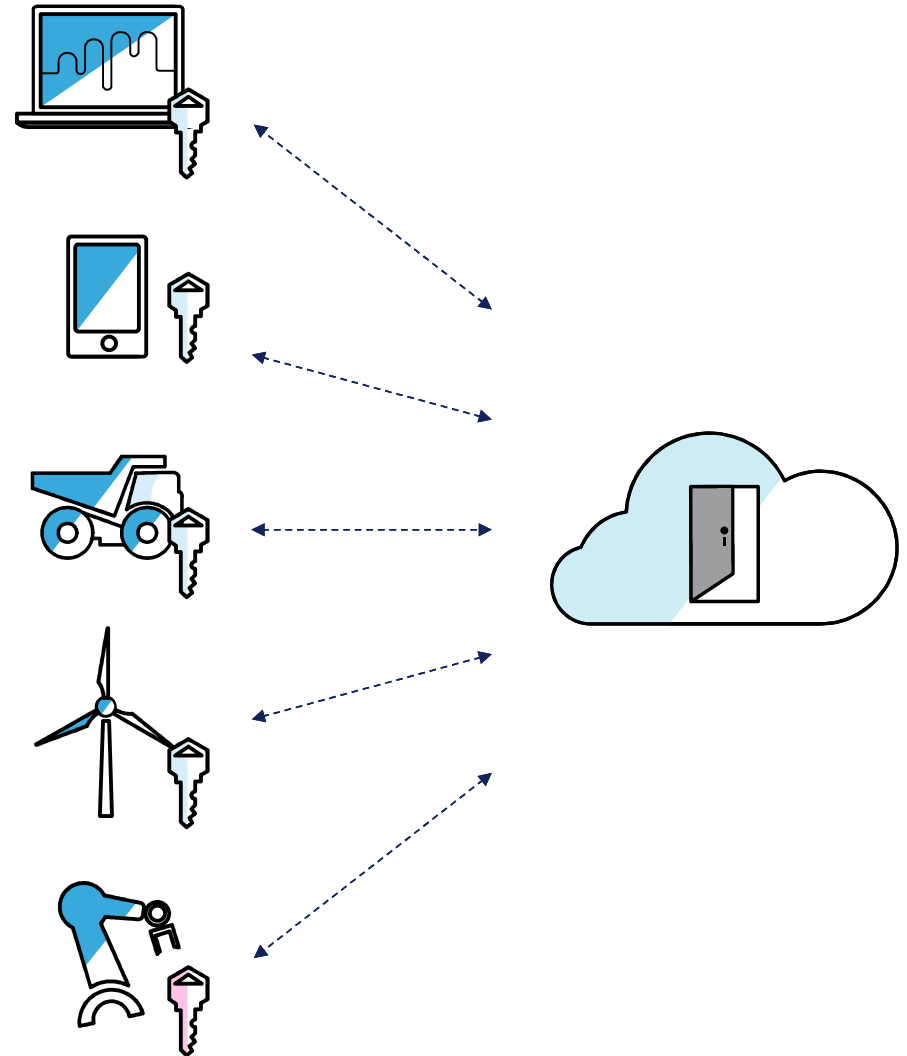
Identity Service

- 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



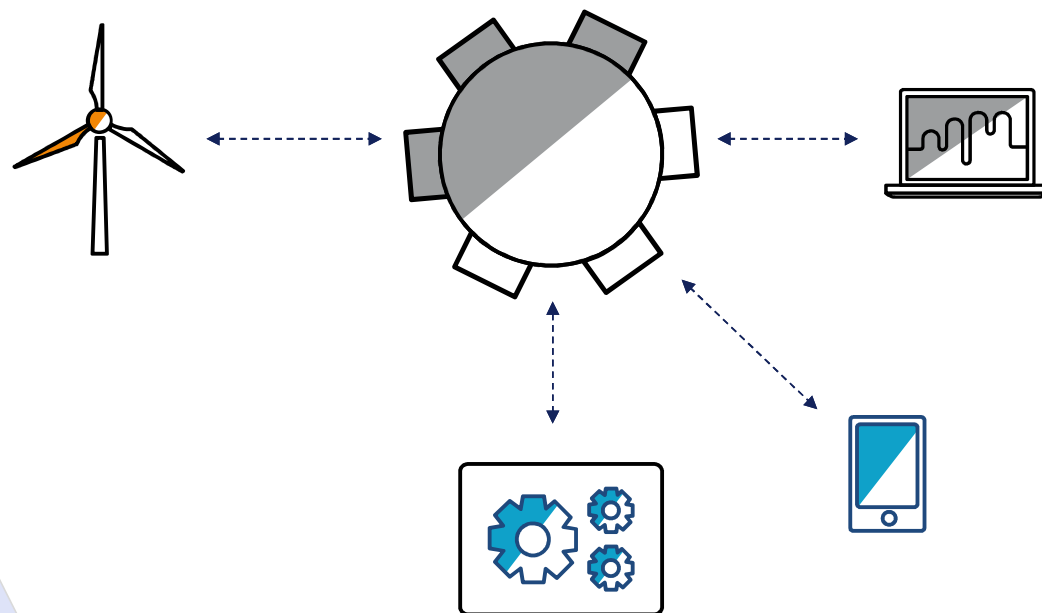
Device Gateway

- 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 Authorizers)
- Secure communications over TLS 1.2
 - Support for numerous AES and ECDHE cipher suites



Message Broker

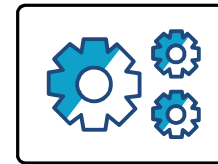
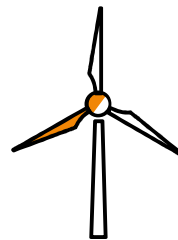
- Scalable, low-latency, reliable message routing based on MQTT protocol
- Two-way message streaming between devices and applications
- Publish/Subscribe for decoupled devices and applications
- Support for QoS0 and QoS1 messaging
- Customizable topic space with support for wildcard topic filters



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.



Analytics
Kinesis



Artificial Intelligence
EMR



Messaging
SQS
SNS



Database
Redshift
DynamoDB

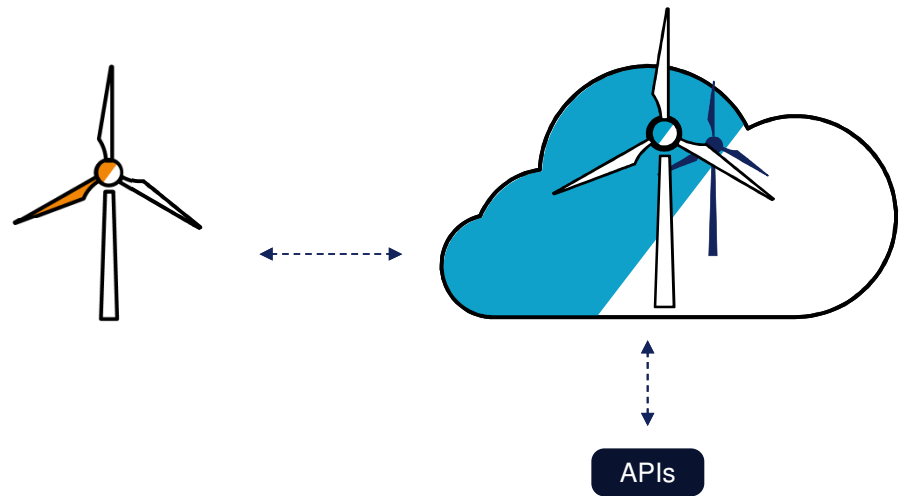


Manage
CloudWatch



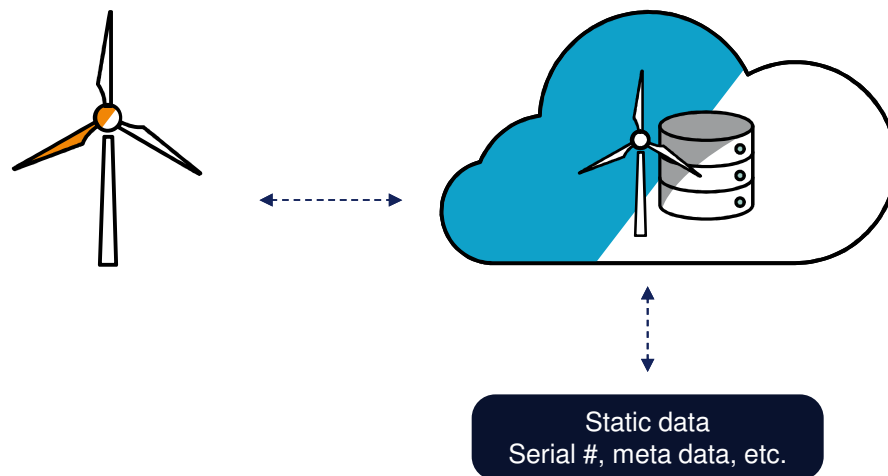
Device Shadow

- 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

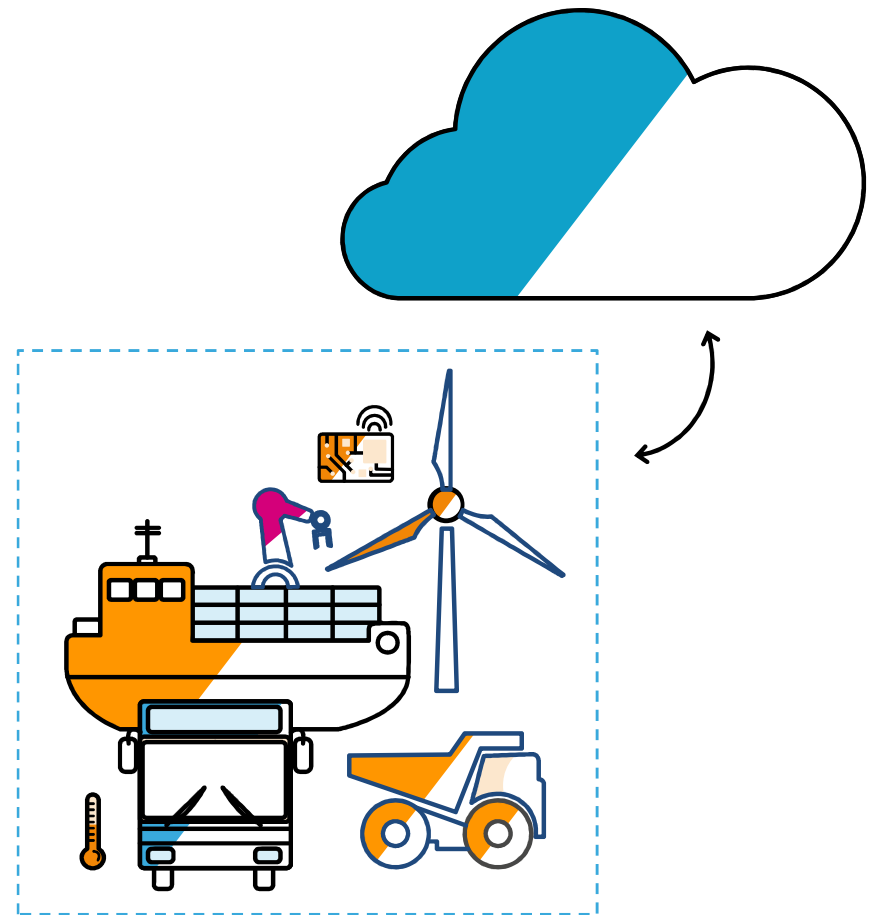


Registry

- 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)



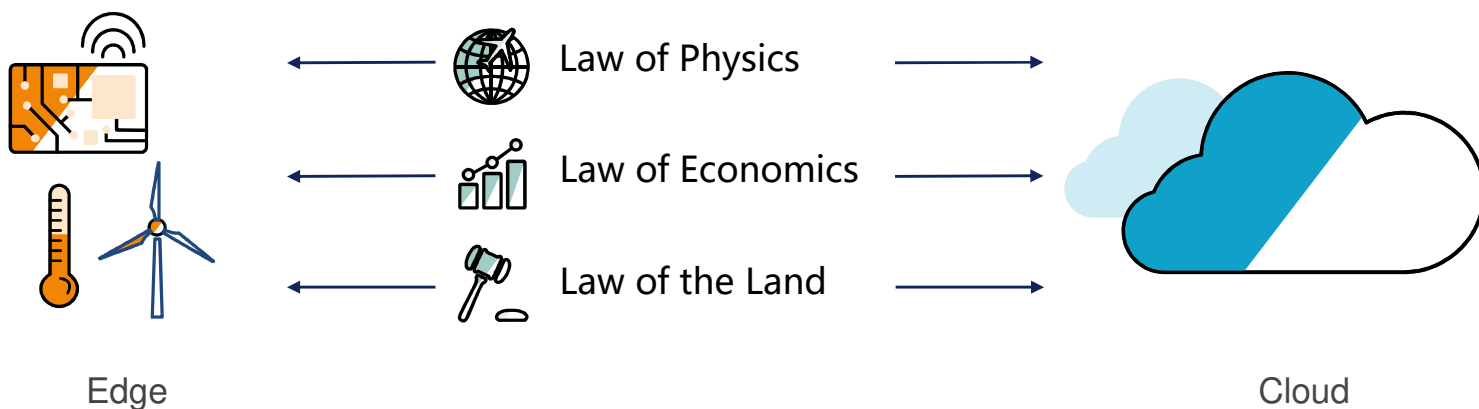
How can I
extend *AWS*
cloud capabilities
to the edge?





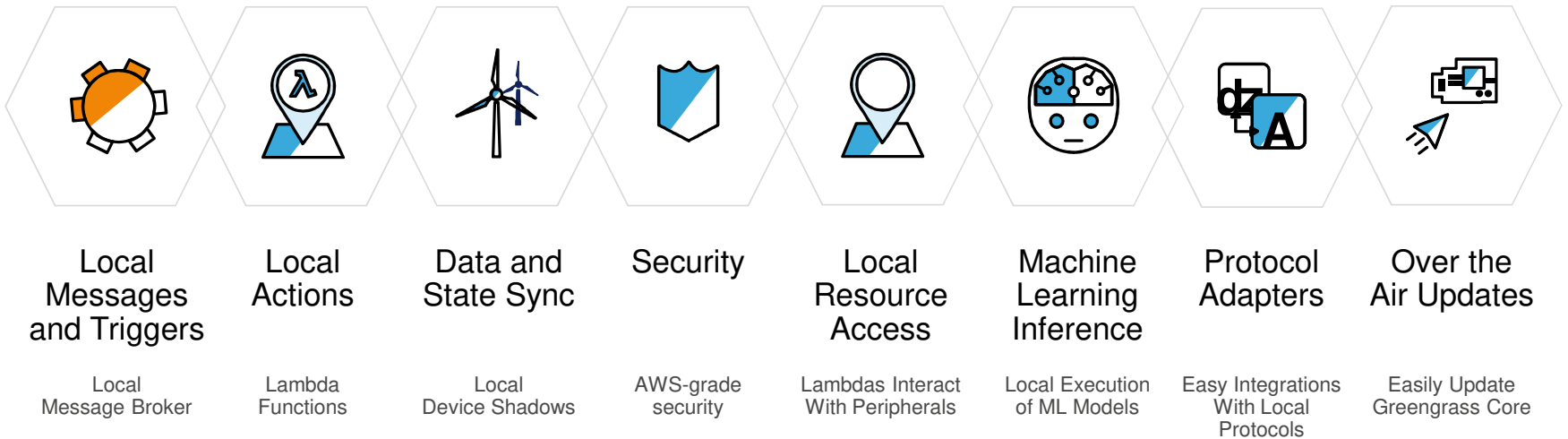
Extend AWS IoT to the Edge

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.

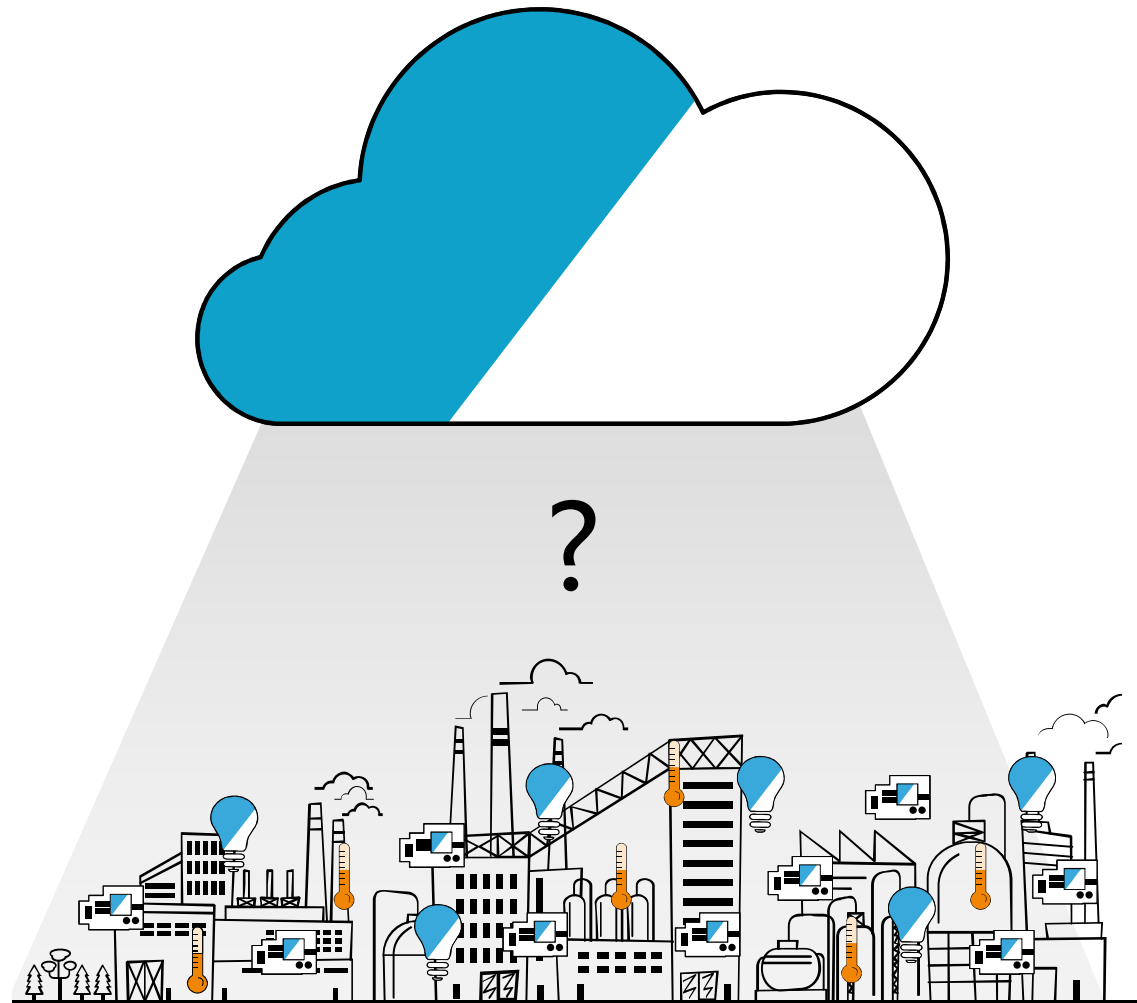




Extend AWS IoT to the Edge



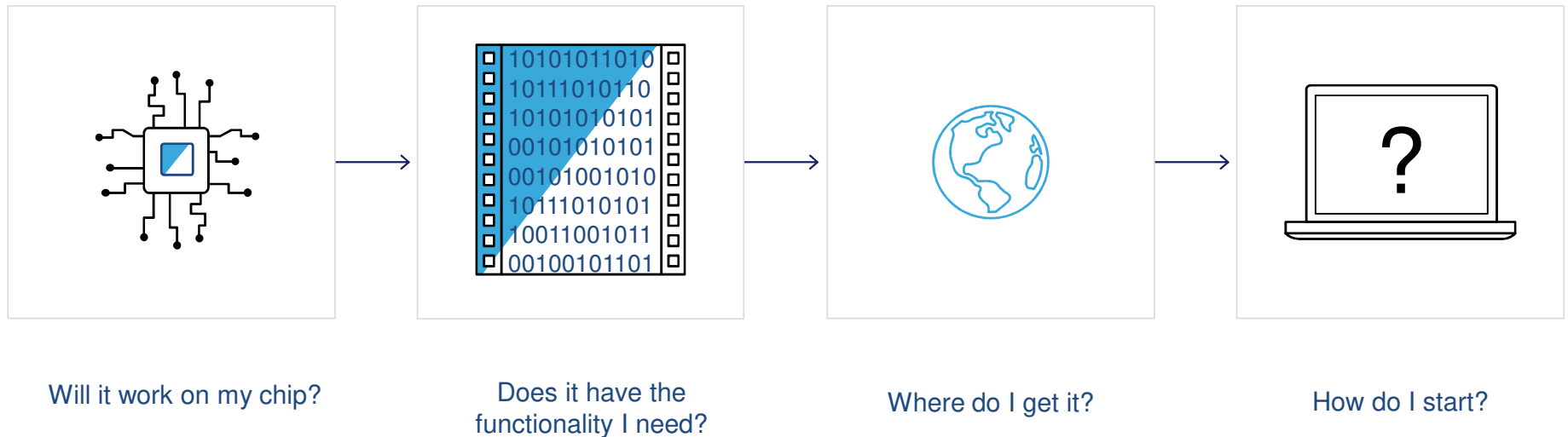
How can I
securely connect
constrained,
microcontroller-
based devices?





IoT Operating System for Microcontrollers

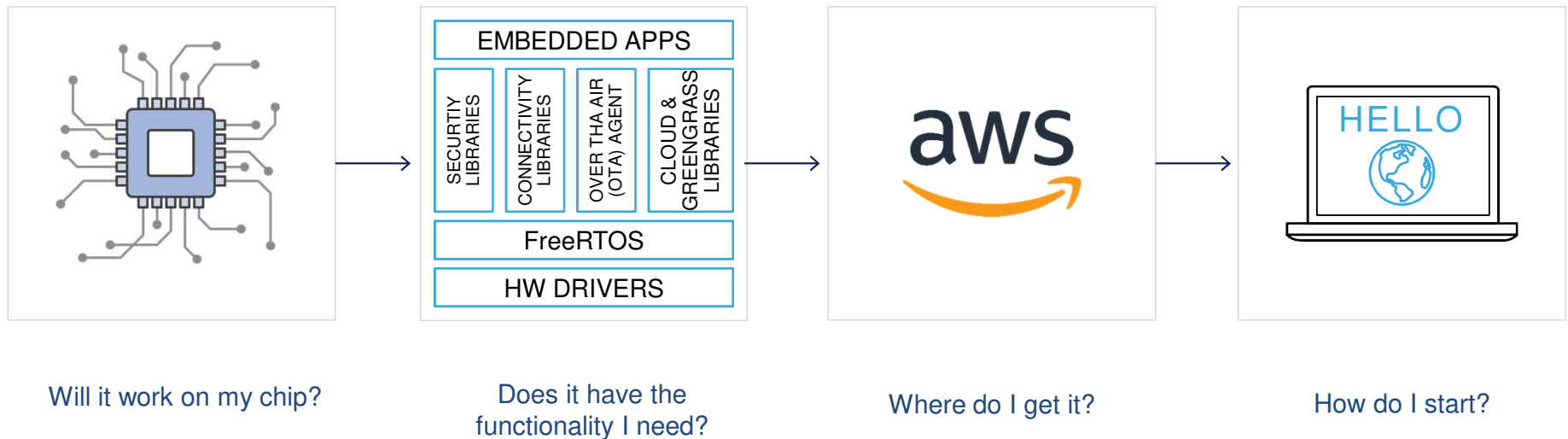
Amazon FreeRTOS, based on the popular FreeRTOS, is a microcontroller operating system that makes small, low powered edge devices easy to program, deploy, secure, connect, and maintain.





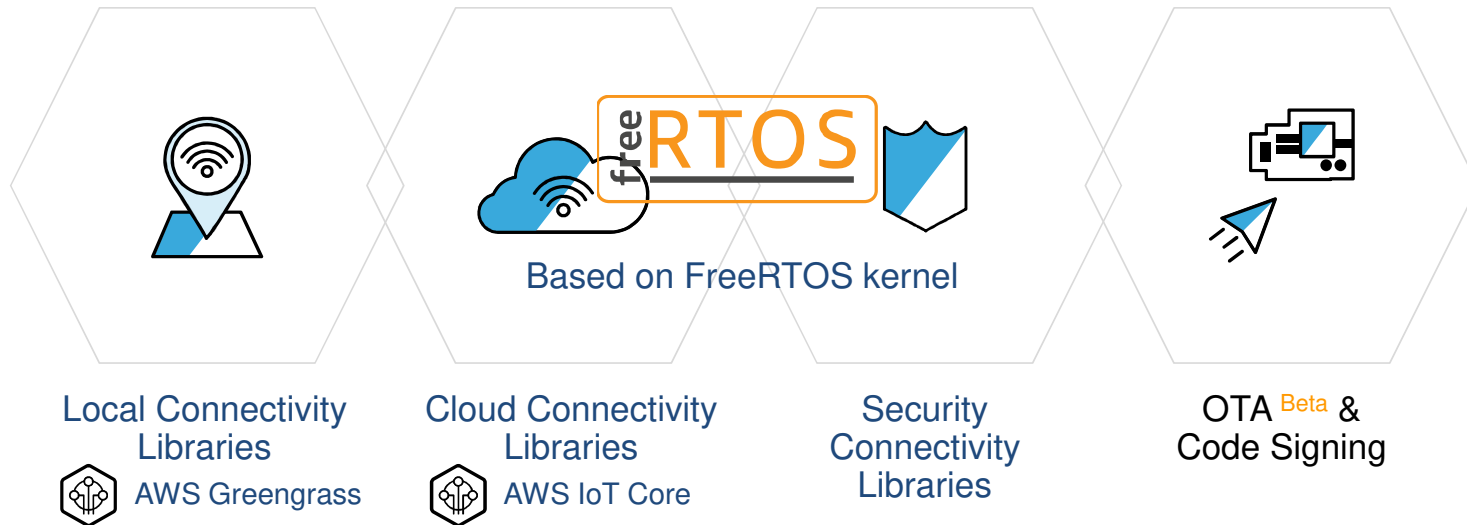
IoT Operating System for Microcontrollers

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.





IoT Microcontroller OS



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



Local Connectivity Libraries

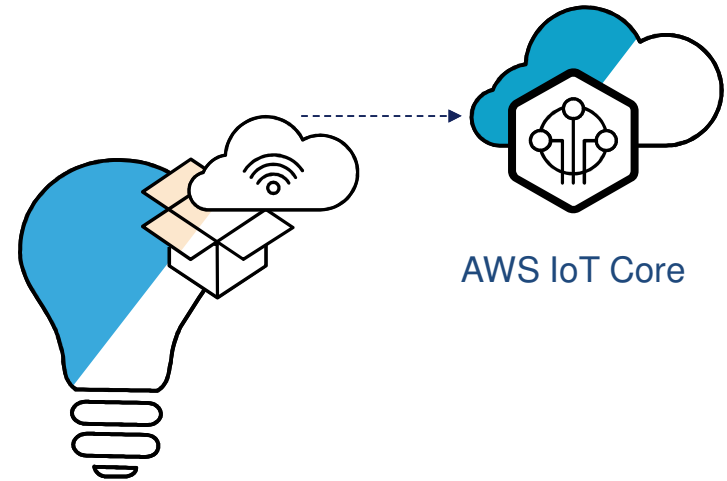
Connect with AWS Greengrass

- 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



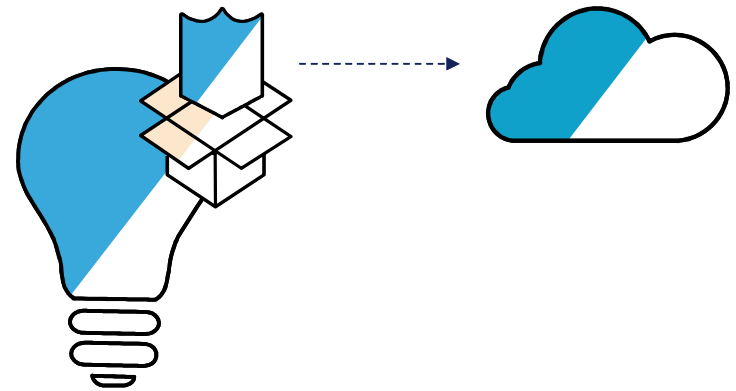
Cloud Connectivity Libraries

- 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



Security Connectivity Libraries

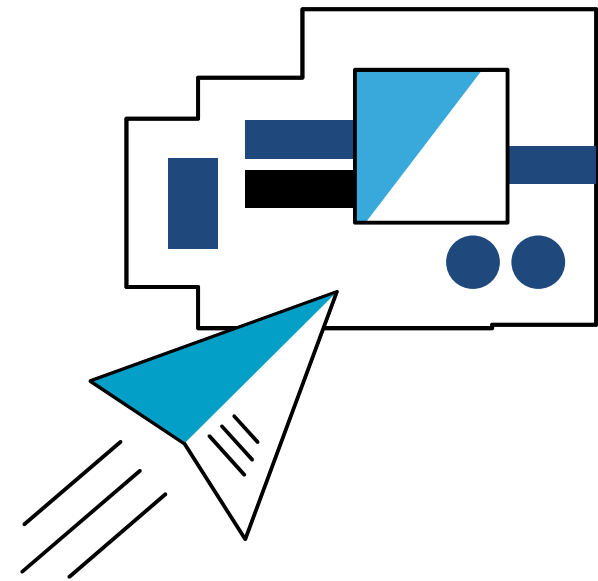
- Secure sockets using TLS
- Certificate-based authentication
- PKCS#11 interface for key management
- Secure by default
- No open network ports
- Only run trusted code
- Clear, modular implementation



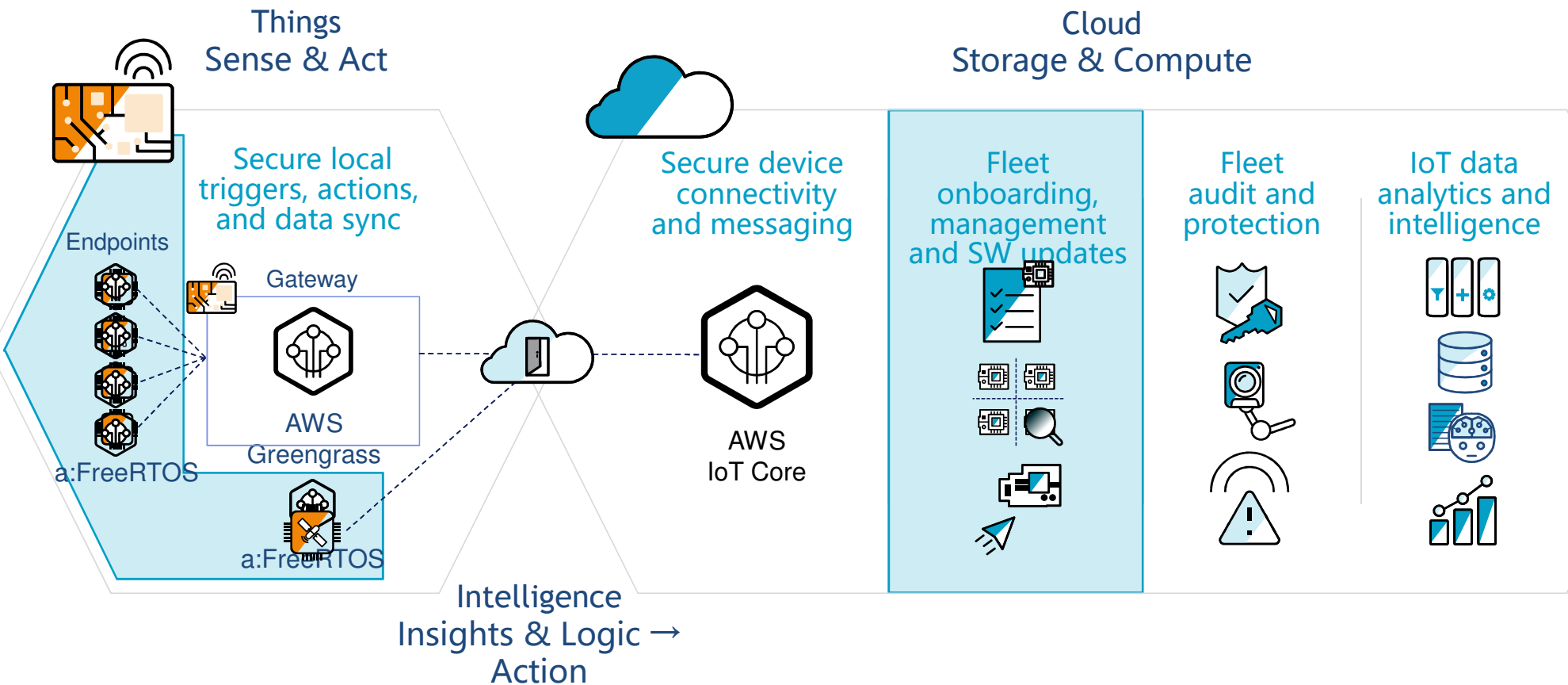
Over-the-Air Firmware Updates

- 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

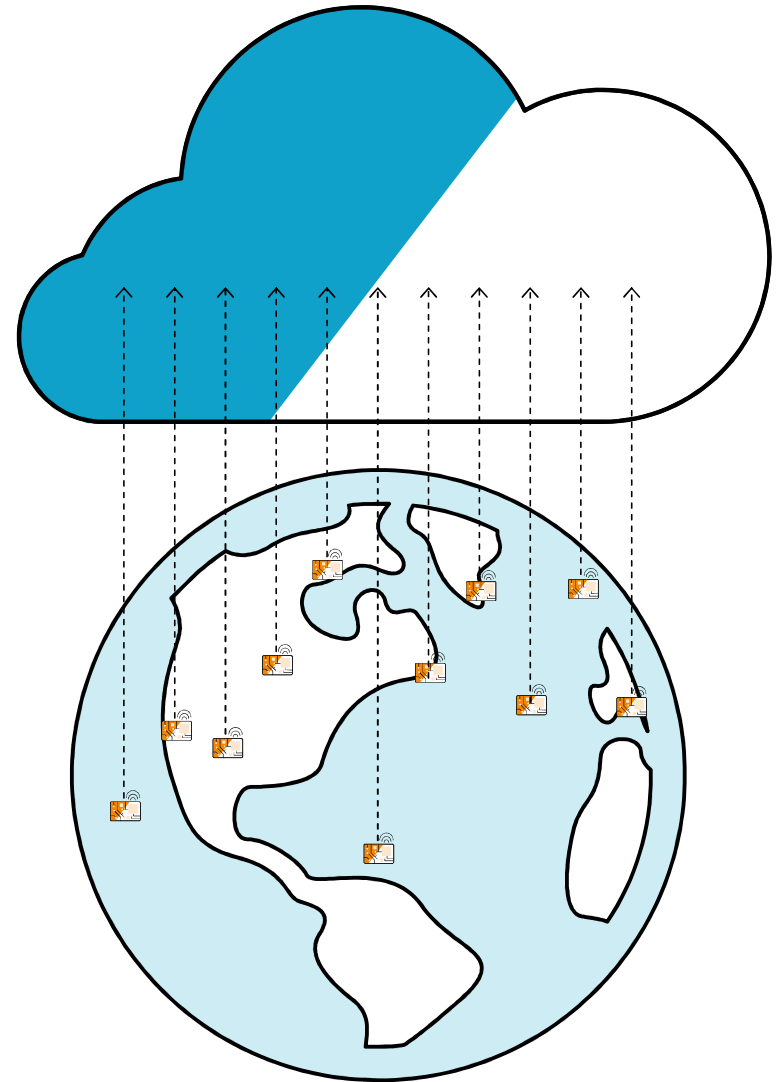
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AWS IoT Architecture



How can I
manage my
growing number
of connected
devices?

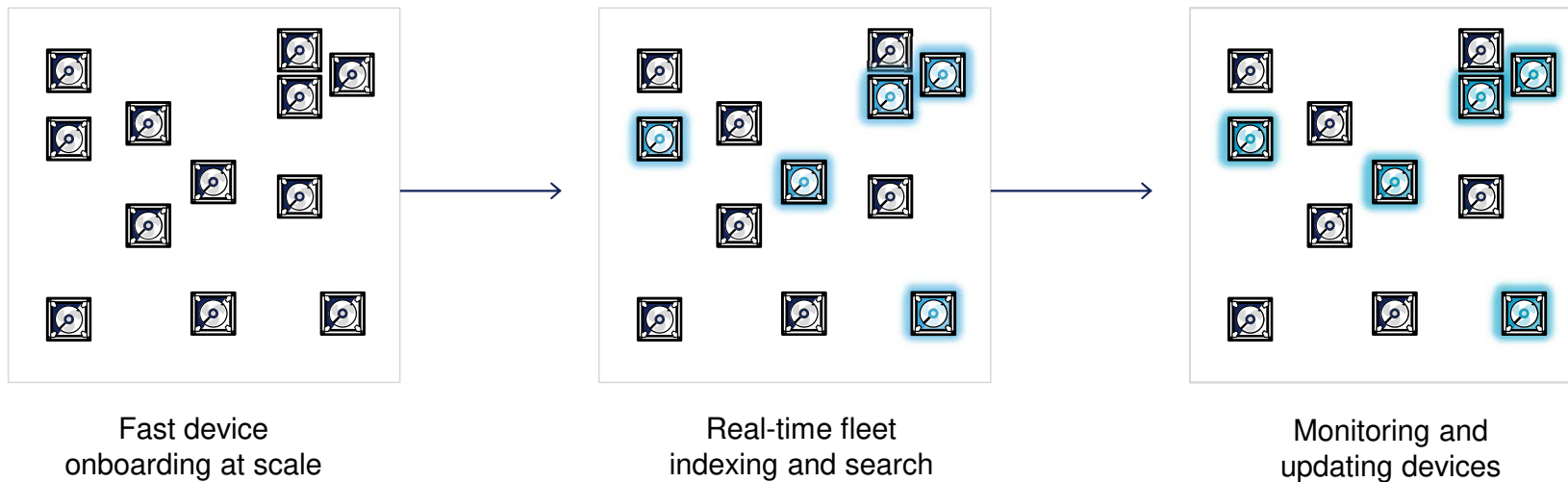




AWS IoT Device Management

Device Management Service

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



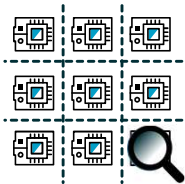


AWS IoT Device Management

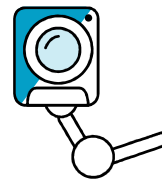
Maintain Fleet Health



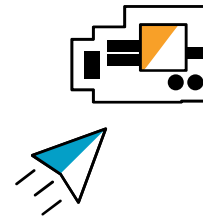
Batch Fleet
Provisioning



Real-time
Fleet Index & Search

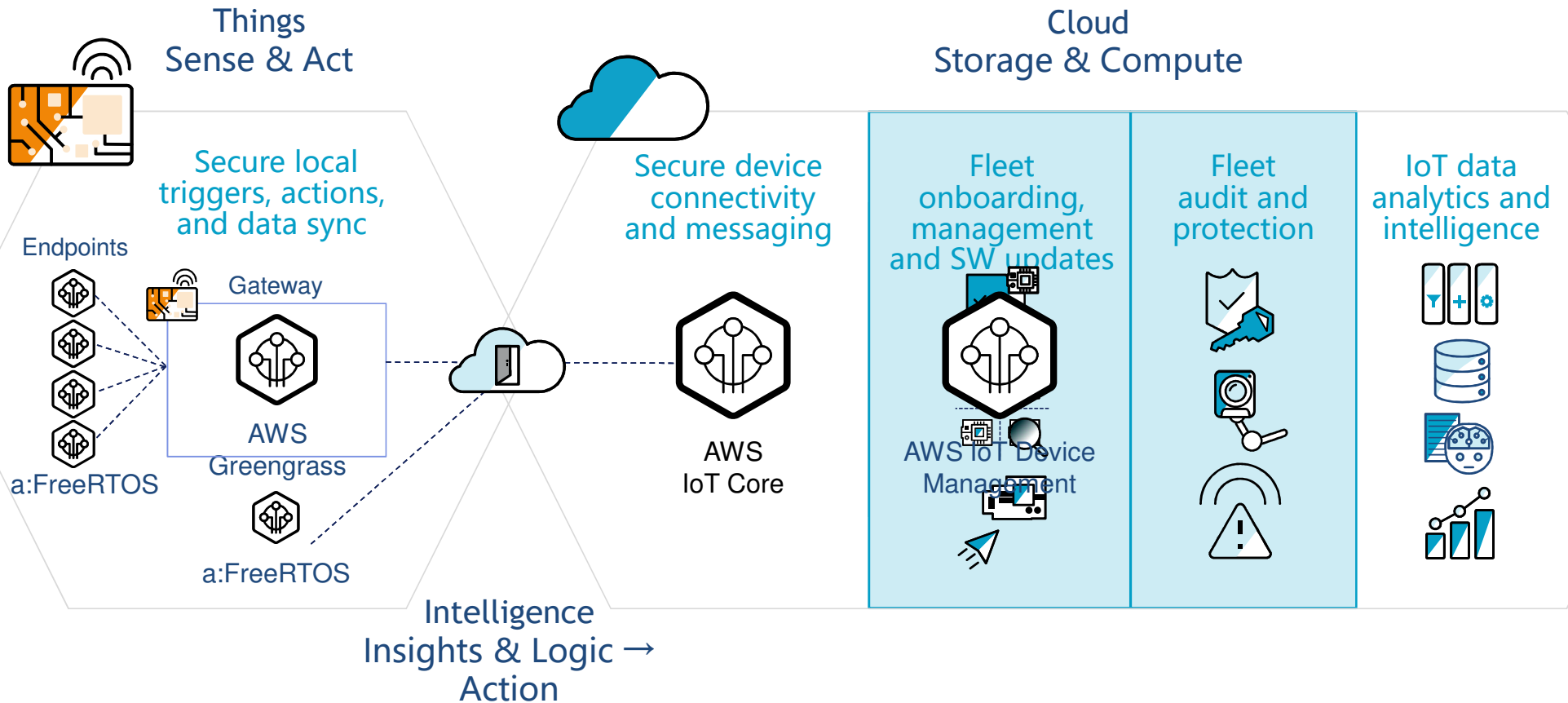


Fine Grained
Device Logging
& Monitoring

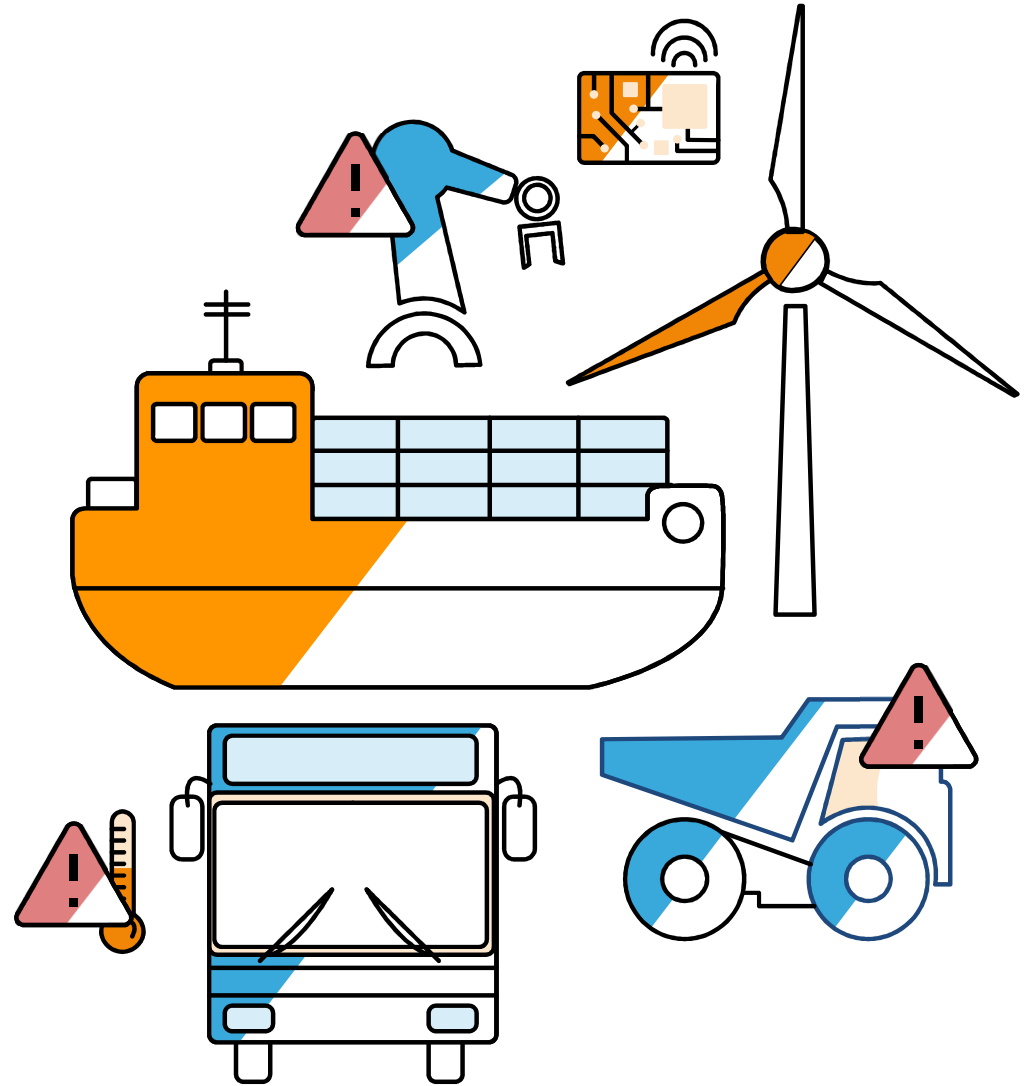


Over the
Air Updates

AWS IoT Architecture



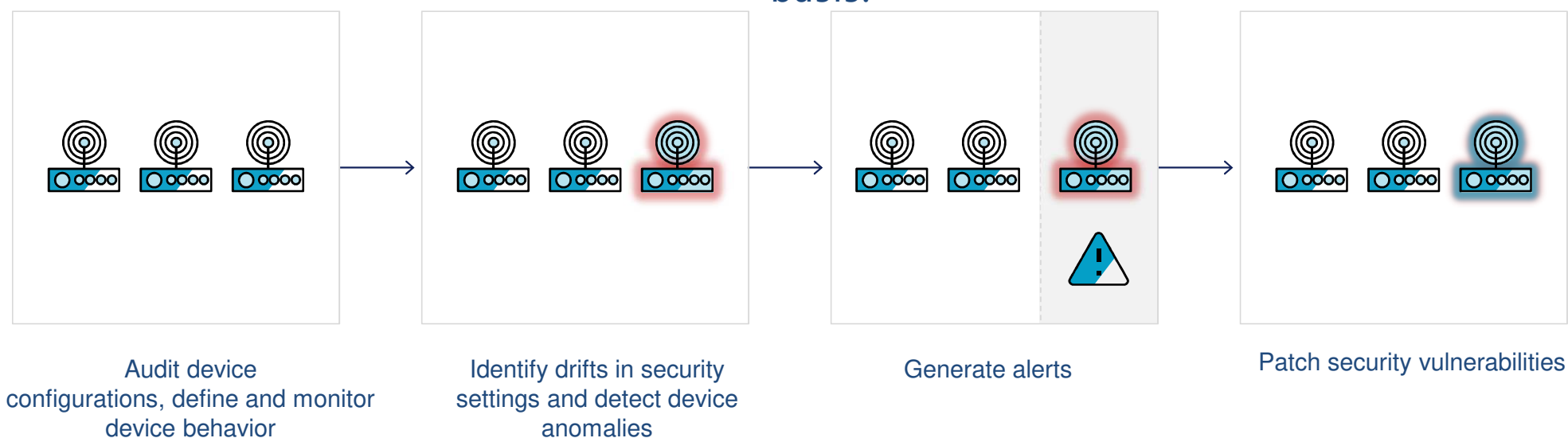
How do I ensure my connected devices stay secure?



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.





AWS IoT Device Defender

Keep Your Fleet Secure



Audit Device
Configurations



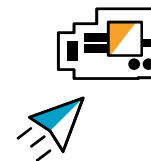
Monitor Device
Behavior



Identify
Anomalies

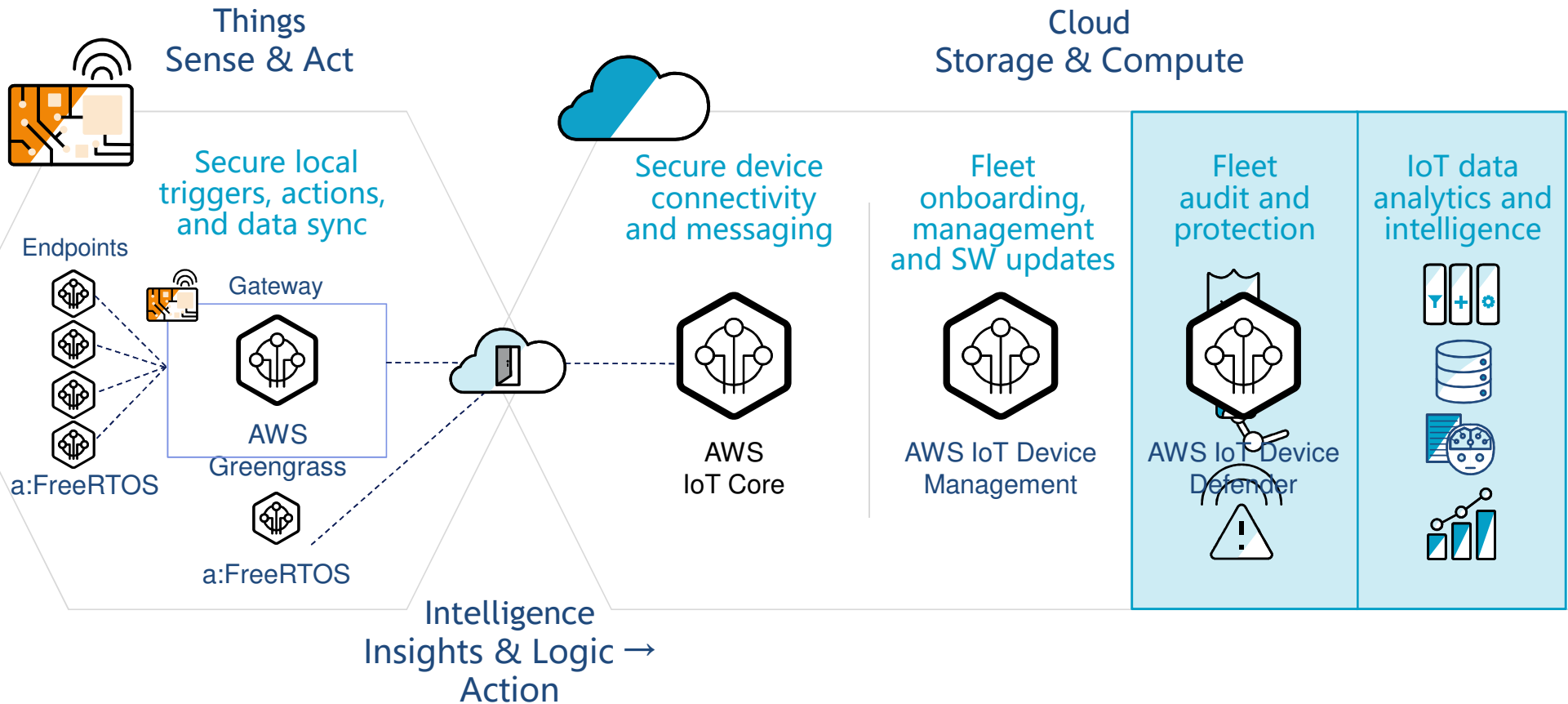


Generate
Alerts

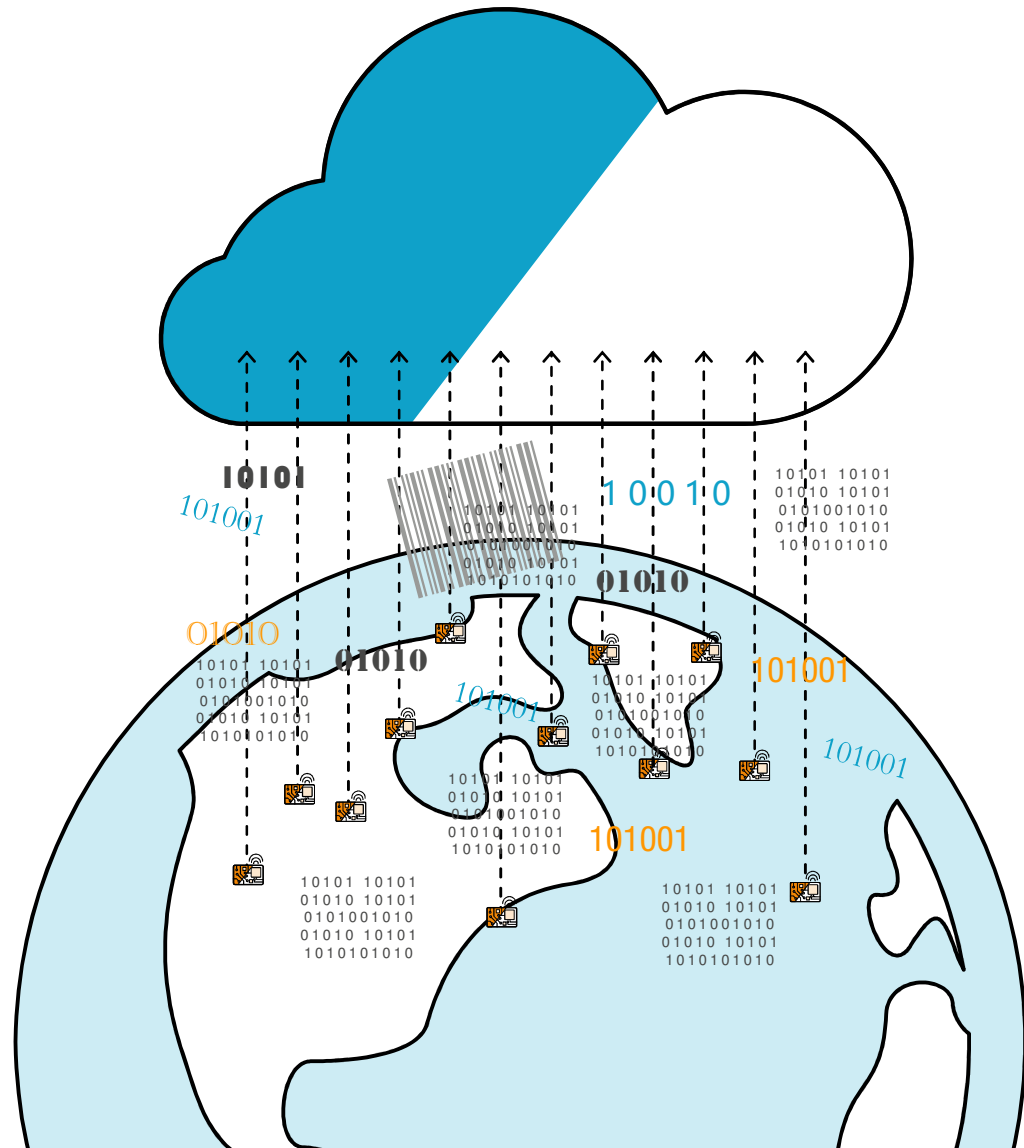


Patch Security
Vulnerabilities

AWS IoT Architecture



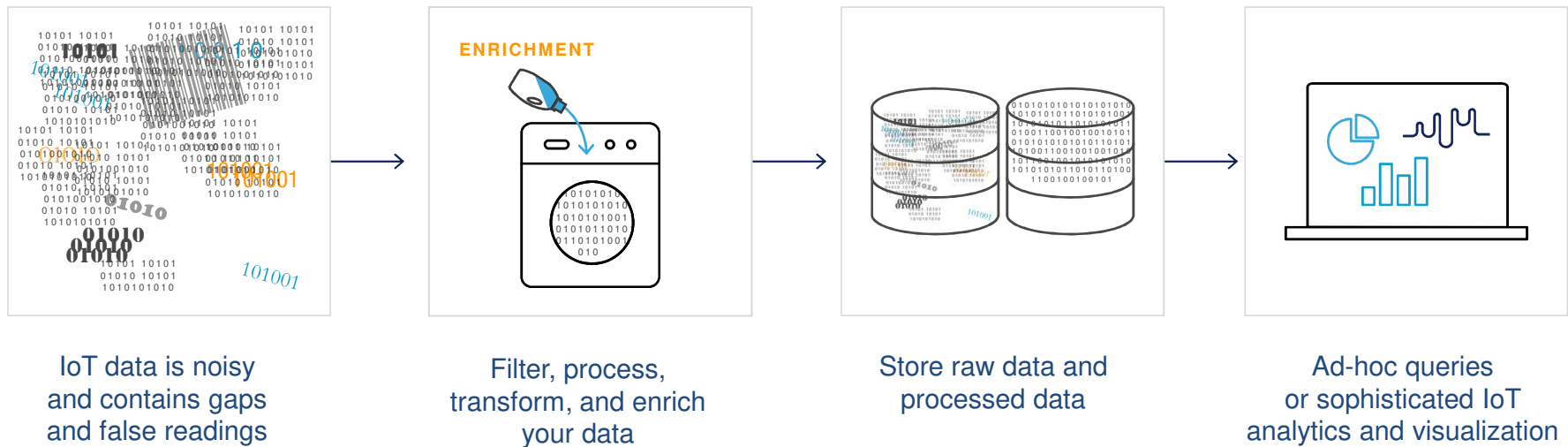
How do I
generate value
from my device
data?





Analytics for IoT Devices

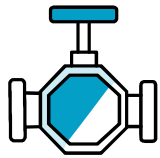
AWS IoT Analytics is a service that processes, enriches, stores, analyzes, and visualizes IoT data for manufacturers and enterprises.



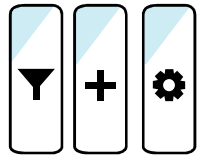


Easily analyze IoT data

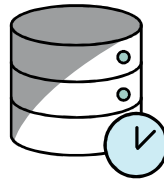
AWS IoT Analytics is a service that processes, enriches, stores, analyzes, and visualizes IoT data for manufacturers and enterprises.



Channels



Pipelines



Data Stores

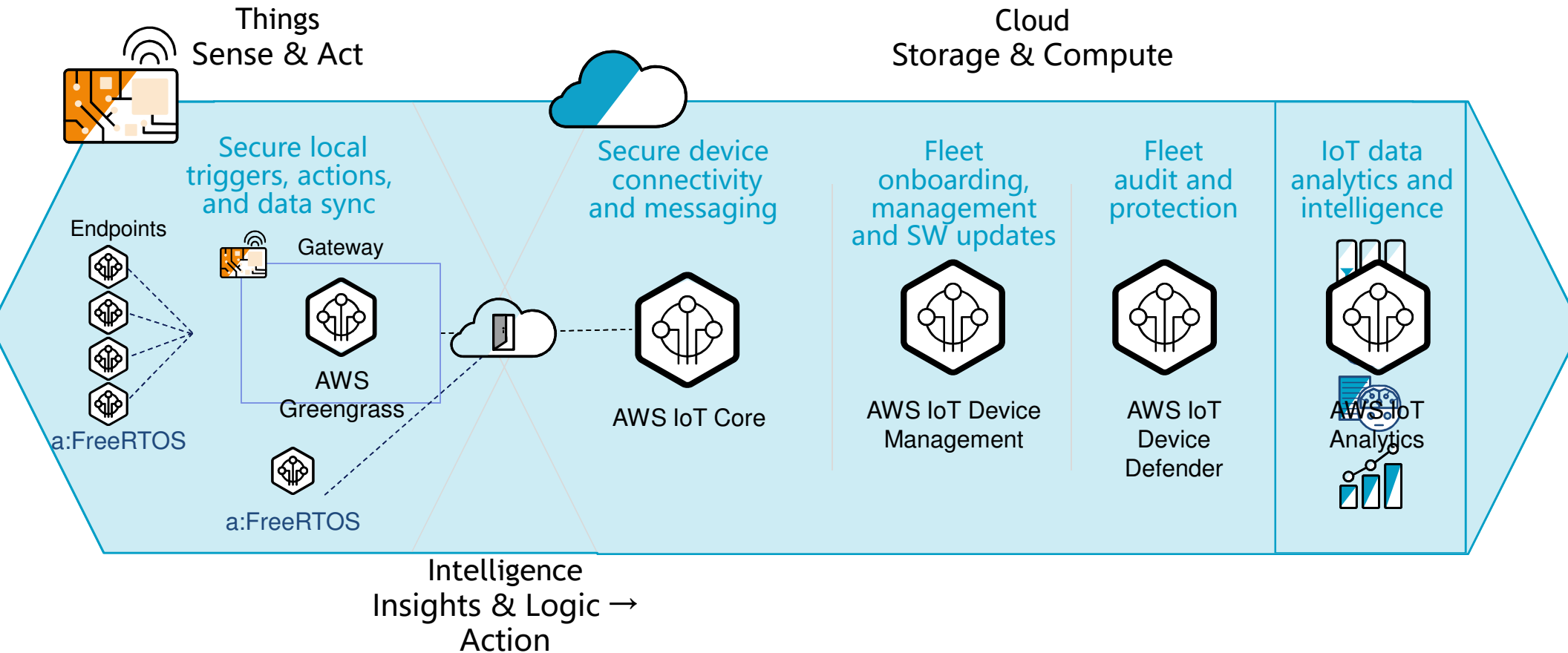


Datasets



Jupyter Notebooks
& Templates

AWS IoT Architecture



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

Releasing Your Creativity

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