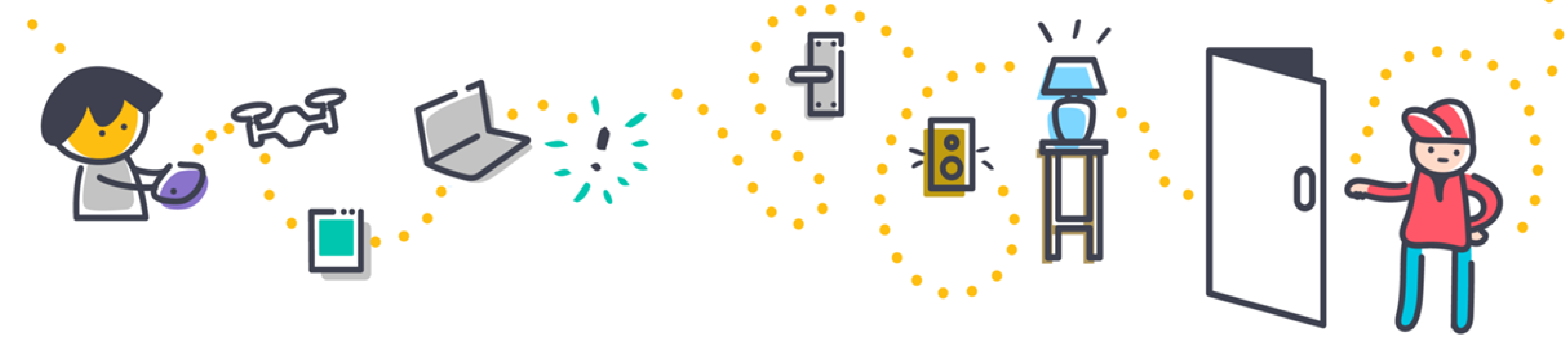
USIM

FACULTY OF SCIENCE AND TECHNOLOGY
Fakulti Sains dan Teknologi
كلية العلوم والتكنولوجيا

</MY_ HACKATHON>
2020

IoT made easy

Bring your Project to Next Level with IoT



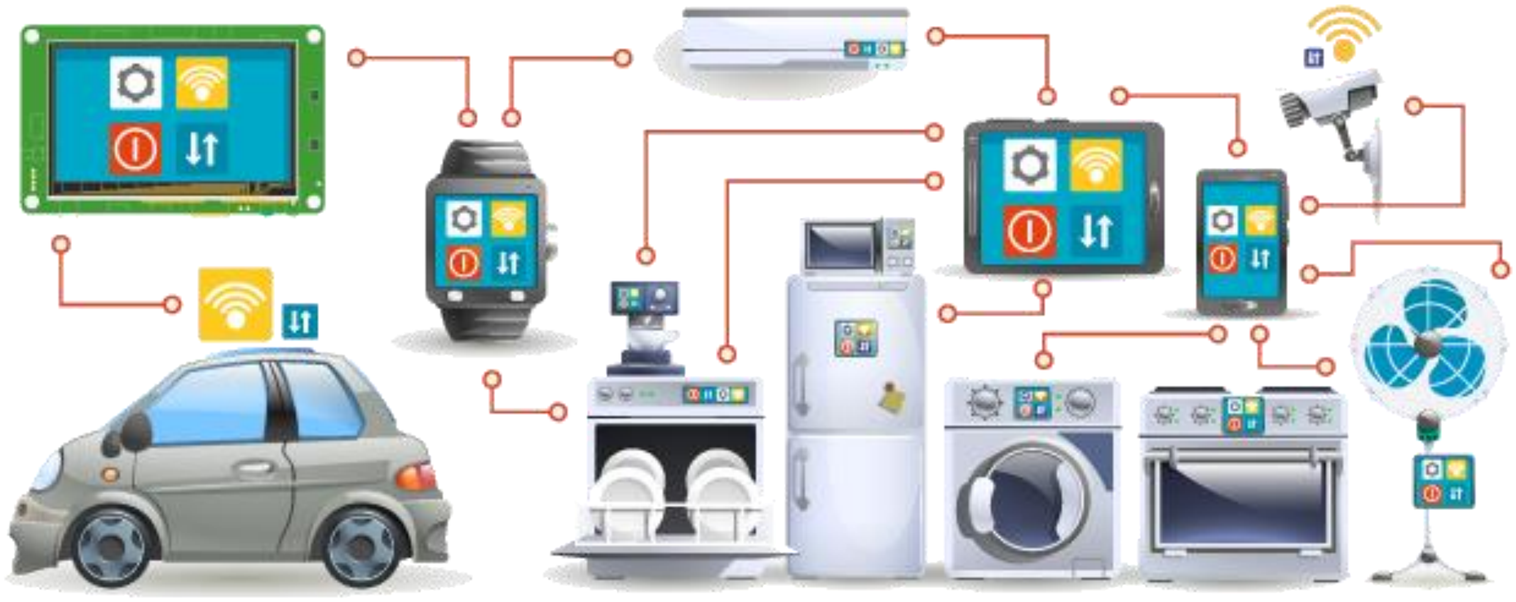
FACULTY OF SCIENCE AND TECHNOLOGY
Fakulti Sains dan Teknologi
كلية العلوم والتكنولوجيا
USIM

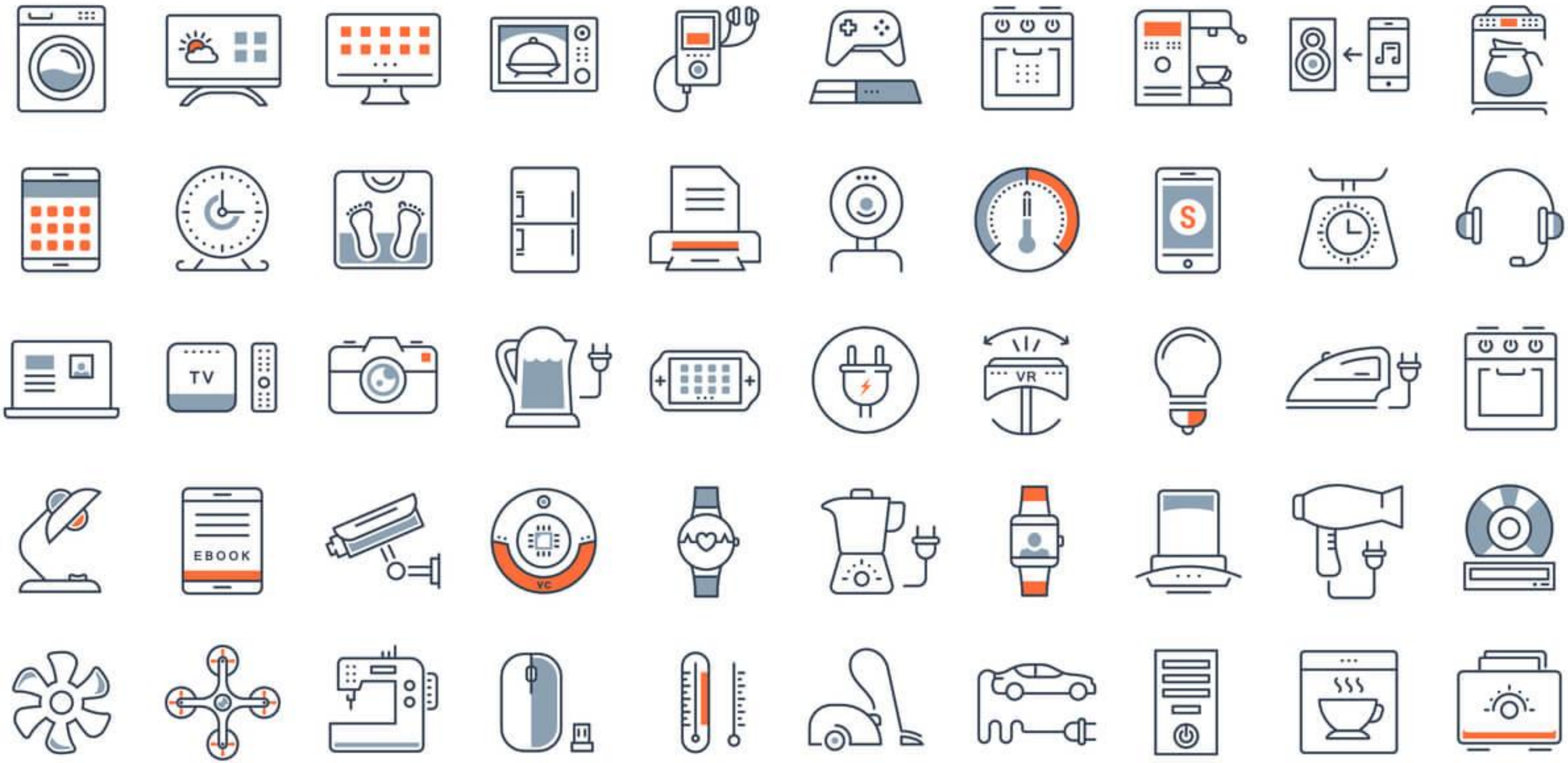
Speaker info

- Dr. Anvar Narzullaev
- Senior Fellow, Faculty of Science and Technology, USIM
  - Information Security and Assurance program
- PhD in Information and Communication Engineering from Yeungnam University, South Korea
- Expertise in Wireless Communication, Machine Learning, IoT
- Contact: t.me/anvarnarz
- Email: anvar@usim.edu.my

What is IoT?

- The Internet of things (IoT) is the extension of Internet connectivity into physical devices and everyday objects:
  - phones, smartwatches, coffee makers, washing machines, headphones, lamps, wearable devices and *almost anything else you can think of.*




TV
VR
S
EBOOK
VC

What is IoT?

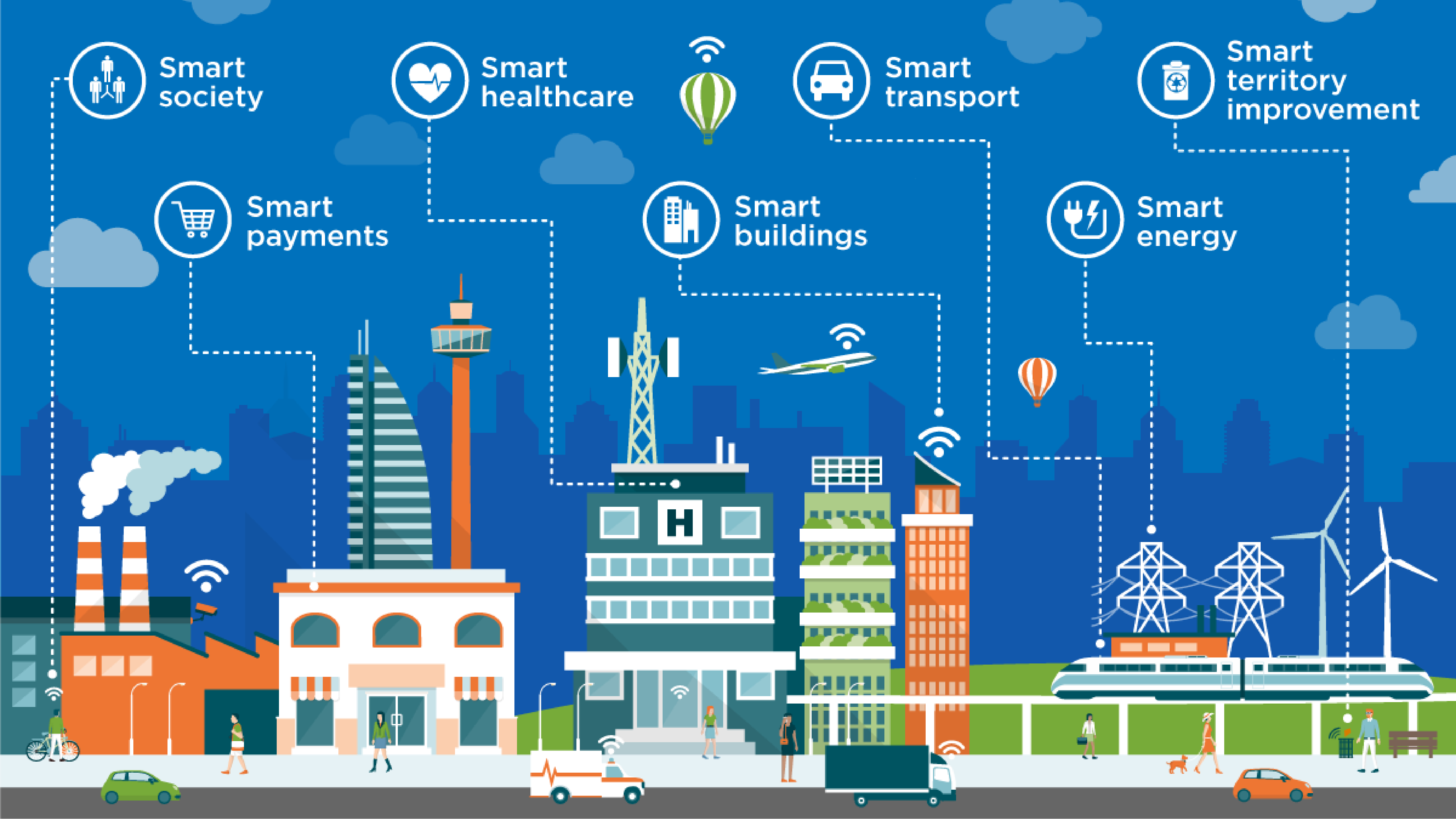
- IoT is the intersection of the digital with the physical.
- Physical devices are now enhanced with sensing, computing, and communication capabilities.
- These enhanced devices are communicating with the digital world, producing data and insights that were never before possible.
- *So is it all about devices (things)?*

What is IoT?

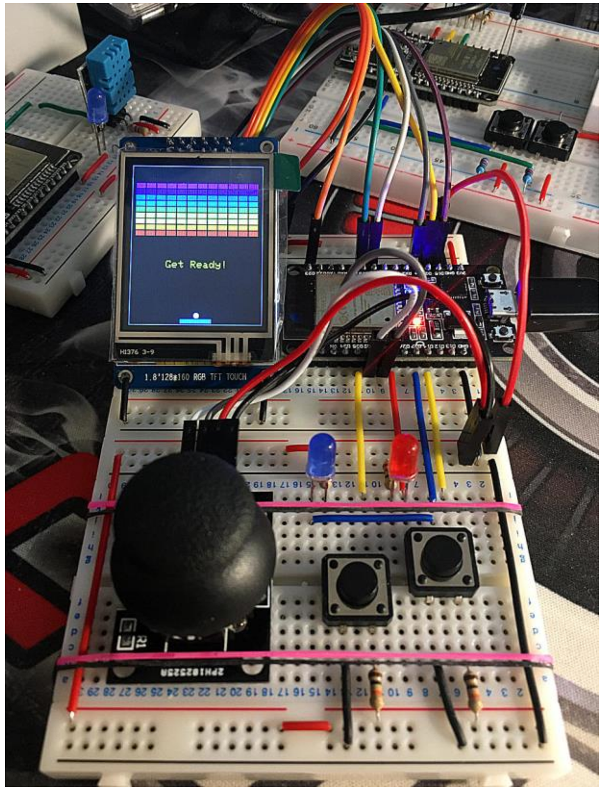
- Consumers are most familiar with the IoT through the products that most affect their day-to-day life.
- IoT is much broader than these narrow examples.
- The IoT is a *system of systems* with each system having unique technology demands.

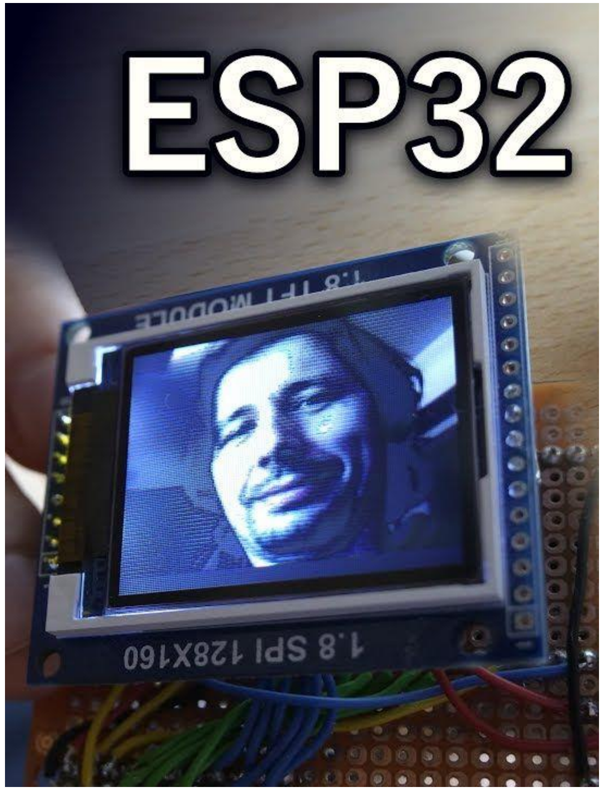
System of Systems

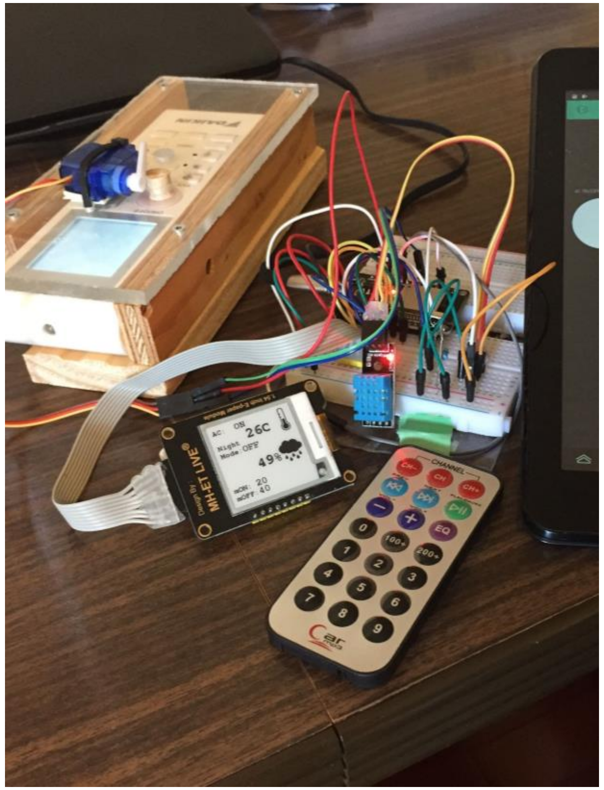
- Data from one system combined with data from other systems create value that you would not have with disconnected systems.

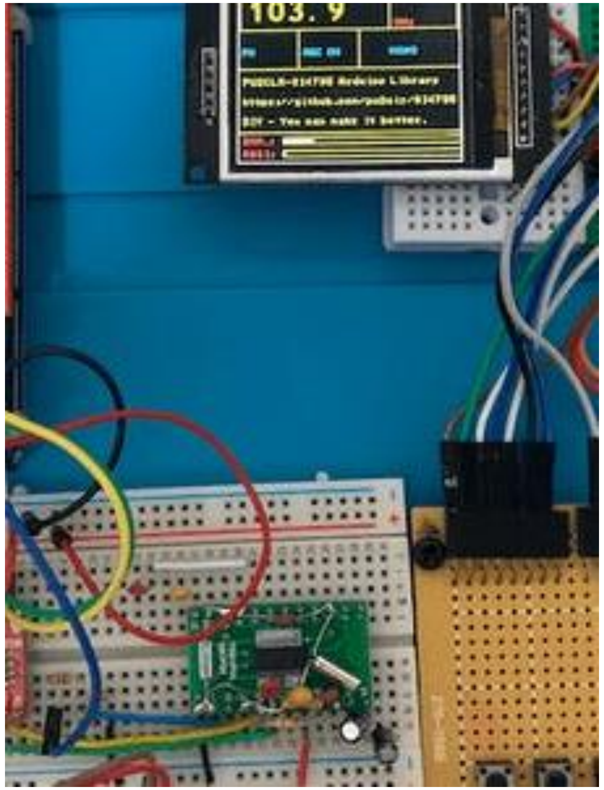

Smart society
Smart healthcare
Smart transport
Smart territory improvement
Smart payments
Smart buildings
Smart energy
H

Why IoT? Why now?









IoT Projects Before

- Wires, circuit boards, electronic components, external sensors, requires soldering
- Mostly for experienced people with engineering or computer science background
- Prototypes had unpresentable look

IoT Projects Today

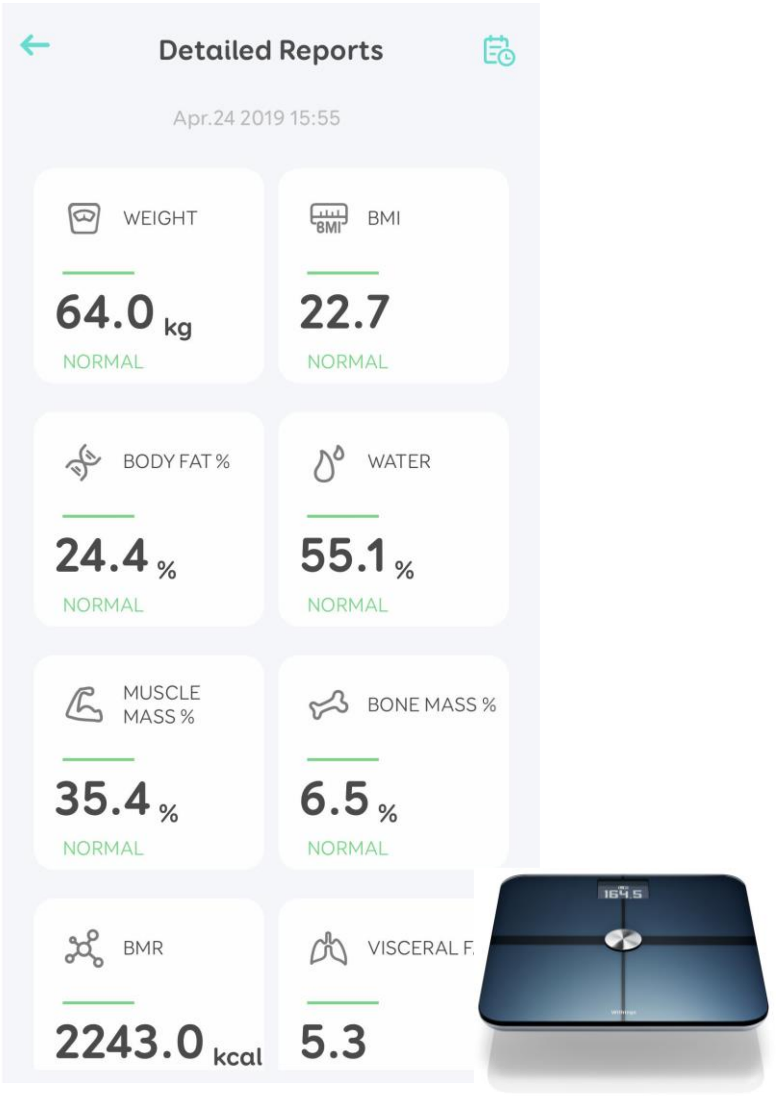
- No more wires, no soldering, devices packed with features and sensors
- Basic knowledge of computer hardware and a little coding experience is more than enough
- Rich libraries and ready-made tutorials suitable for most projects
- Prototypes have finished look

IoT System Components

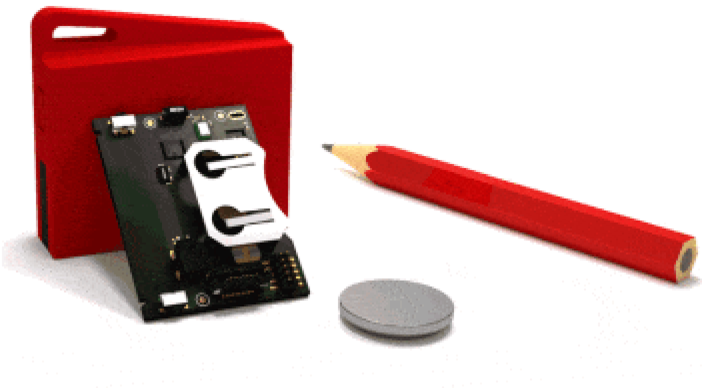
PHYSICAL THINGS

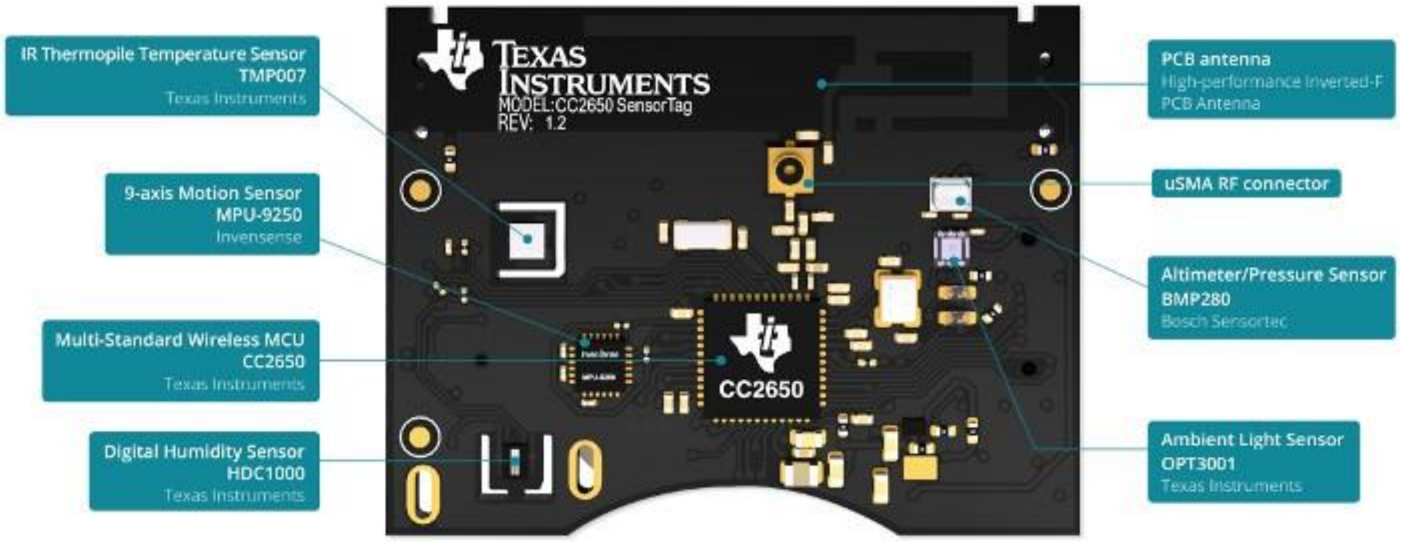
Physical Things

- The intelligence and value from IoT is based on what can be learned by studying data
- The fundamental source of IoT data is ***sensors***
- Driven by innovations in materials and nanotechnology sensor technology is developing very fast
  - Increased accuracy, decreased size, low cost, long battery life
- New sensors can measure things that were not previously possible



Physical Things

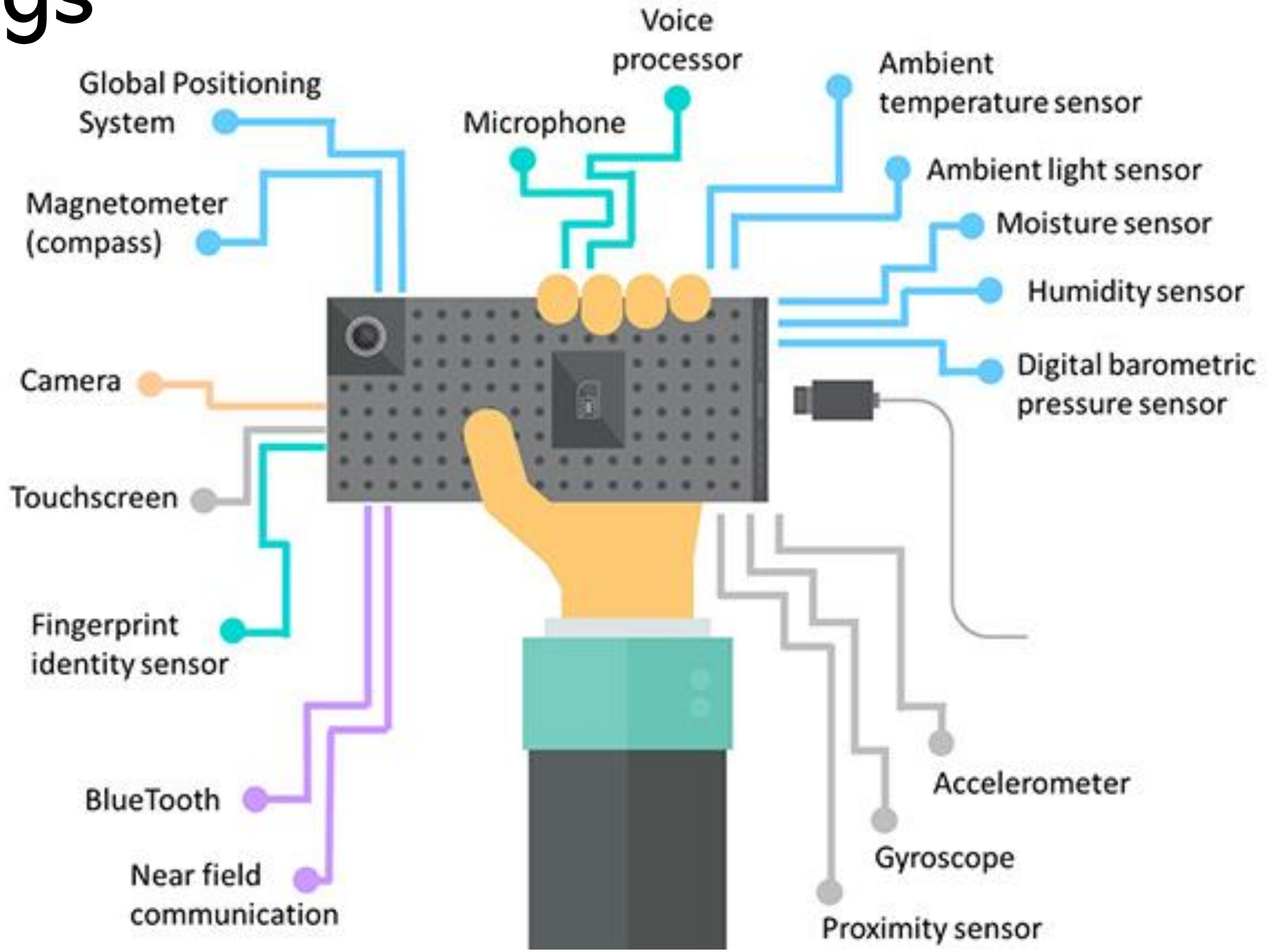




- ambient light
- digital microphone
- magnetic sensor
- humidity
- pressure
- accelerometer
- gyroscope
- magnetometer
- object temperature
- ambient temperature

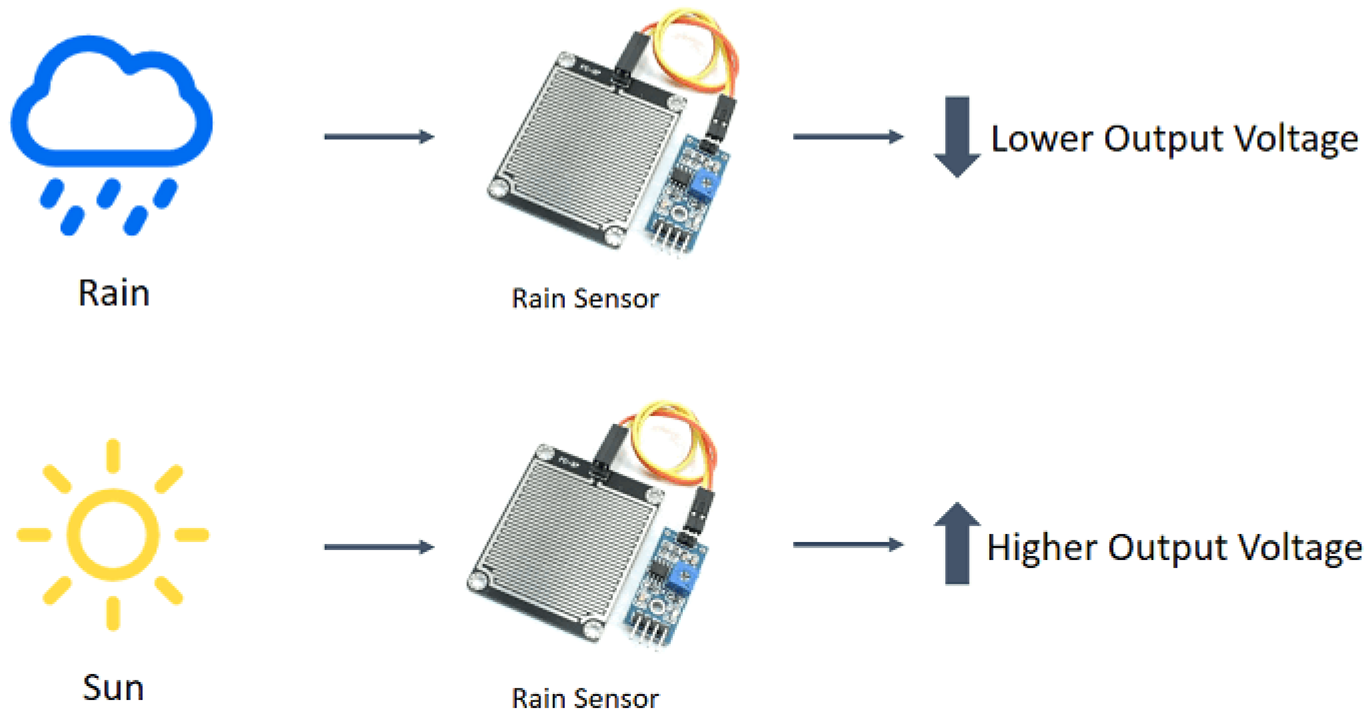
2 years
Battery Life

Physical Things



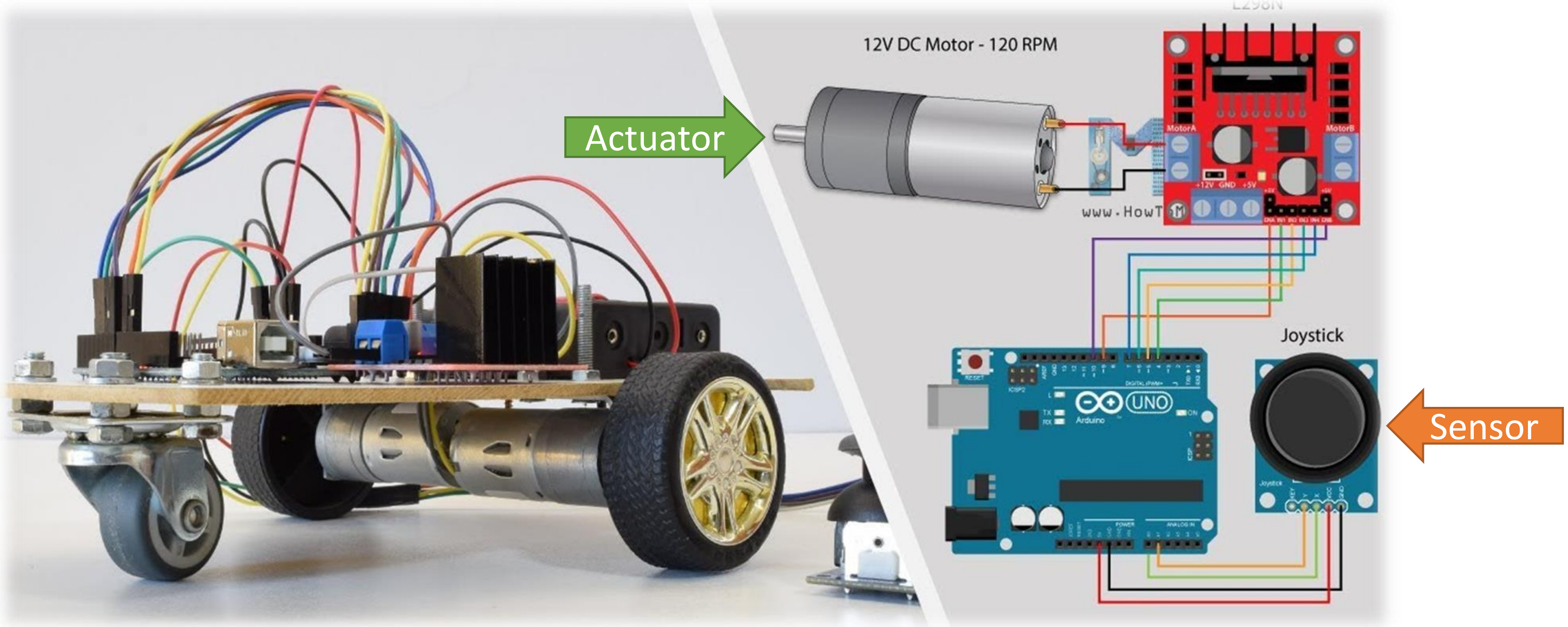
Sensors and actuators

- A sensor is a device that converts physical phenomenon into an electrical impulse that can then be interpreted to determine a reading.



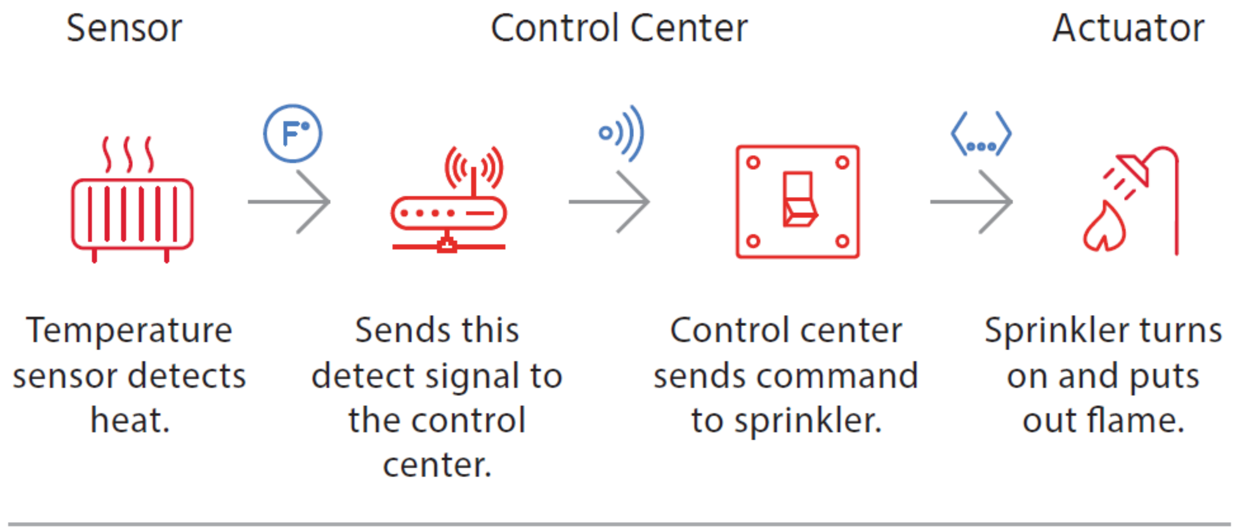
Sensors and actuators

- Actuator operates in the reverse direction of a sensor.
- It takes an electrical input and turns it into physical action.



Sensors to Actuator Flow

- In typical IoT systems a sensor may collect information and route to a control center where a decision is made and a corresponding command is sent back to an actuator in response to that sensed input.



Sensor to **Actuator** Flow

Sensors and actuators

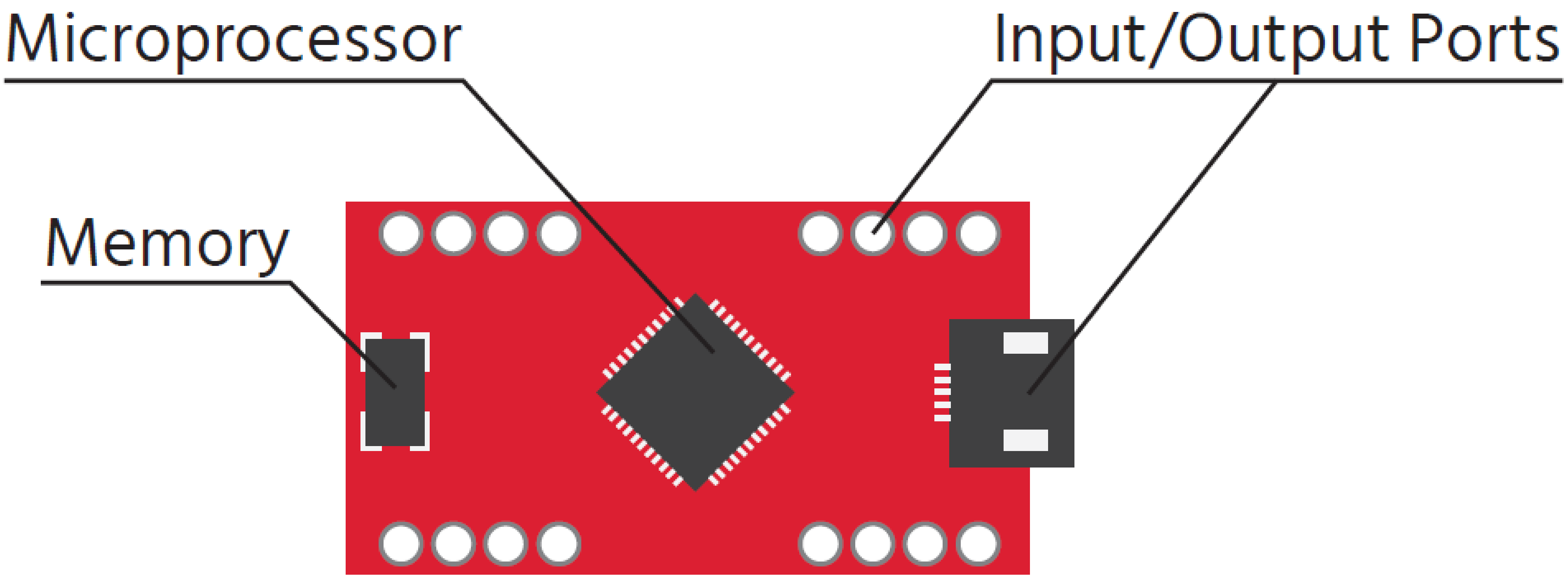
The Control System

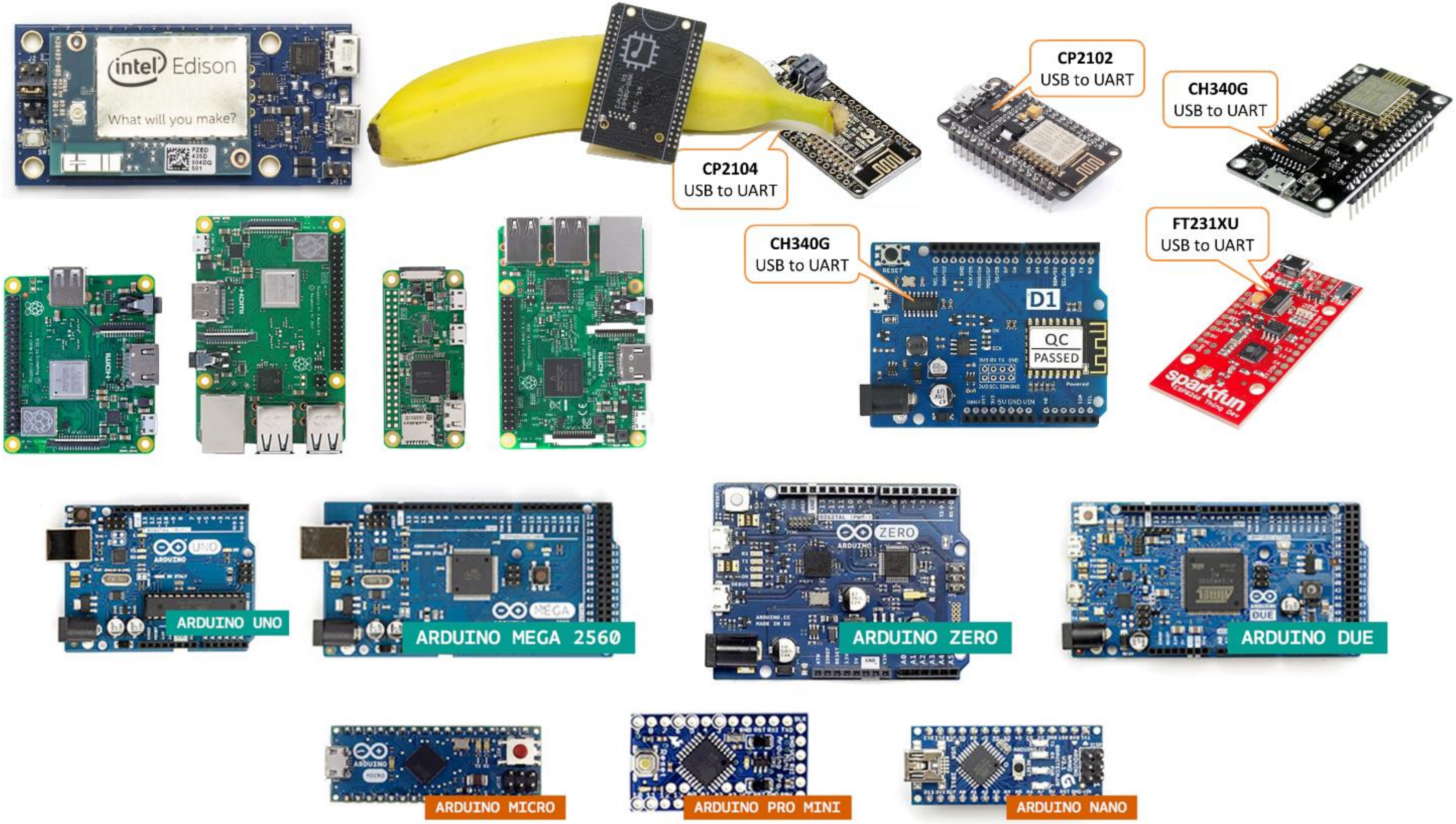
- Regardless of the function, environment, or location, your IoT device requires two components, a **brain** and **connectivity**.
- The "brain" provides local control (or decision-making).
  - Your device's function will determine the size and capabilities of the brain component.
- Connectivity is needed to communicate with external control.
  - The environment and location of your device will determine how it connects.

The “Brain” of the IoT Device

- Your IoT device will most likely use a *microcontroller* as its brain.
- Microcontroller is a small computer with a microprocessor, memory and input/output ports
  - Microprocessor is a CPU
  - Memory includes ROM and RAM
  - I/O ports may be either digital or analog
    - receive data from sensors
    - send signals to actuators

The “Brain” of the IoT Device



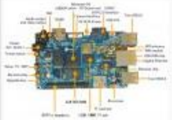


intel Edison
What will you make?
CP2104
USB to UART
CP2102
USB to UART
CH340G
USB to UART
CH340G
USB to UART
FT231XU
USB to UART
D1
QC
PASSED
sparkfun
ARDUINO UNO
ARDUINO MEGA 2560
ARDUINO ZERO
ARDUINO DUE
ARDUINO MICRO
ARDUINO PRO MINI
ARDUINO NANO

How to choose a right microcontroller?

- Depending on your application consider following things:
  - Microprocessor type
    - How fast (clock speed), how much information it handles (bus size)
  - Amount of memory
    - ROM to store you program (code)
    - RAM to send/receive data to/from CPU
  - Number of I/O ports
    - Number of sensors and actuators to support
    - Number of digital and analog I/O ports
  - Power
  - Control interface to communicate between sensors-brains-actuators
  - Dev Support and Community
  - Cost

How to choose a right board?

	Raspberry Pi 3	Raspberry Pi Zero	Raspberry Pi Zero W	Asus Tinker Board	Orange PI 3	Orange Pi Plus 2	ODROID-C2	CHIP	Banana Pi	Arduino Uno rev. 3	Adafruit Metro
Image											
Height	3.37 in (85.6 mm)	1.18 in (30 mm)	1.18 in (30 mm)	2.22 in (56.5 mm)	3.68 in (93.5 mm)	2.63 in (67 mm)	2.20 in (56 mm)	1.57 in (40 mm)	2.36 in (60 mm)	2.09 in (53.3 mm)	2.16 in (55 mm)
Width	2.22 in (56.5 mm)	2.55 in (65 mm)	2.55 in (65 mm)	3.37 in (85.6 mm)	2.36 in (60 mm)	4.25 in (108 mm)	3.34 in (85 mm)	2.36 in (60 mm)	3.62 in (92 mm)	2.70 in (68.6 mm)	2.71 in (68.9 mm)
Weight	1.58 oz (45 g)	0.31746 oz (9 g)	0.31746 oz (9 g)	1.94 oz (55 g)	2.64 oz (75 g)	2.92 oz (83 g)	1.41 oz (40 g)		1.69 oz (48 g)	0.88184 oz (25 g)	0.58202 oz (16.5 g)
Price	US$35.00	US$5.00	US$10.00	US$69.00	US$35.00	US$49.00	US$46.00	US$9.00			US$19.50
Technical details											
CPU	1.2GHz 64-bit quad-core ARMv8	1 GHz Low Power ARM1176JZ-F	1 GHz Low Power ARM1176JZ-F	1.8GHz Quad core ARM Cortex-A17 32bit	Allwinner H6 SoC quad-core 64bit 1.8Ghz	1.6 GHz H3 Quad-core Cortex-A7 H.265/HEVC 4K	1.5GHz Quad Core Cortex-A53 64 Bit ARMv8	1 GHz Allwinner A13 Compatible SoC	1 GHz ARM Cortex-A7 dual-core	16MHz ATmega328P	
GPU	Broadcom VideoCore IV @ 300 MHz	Dual Core VideoCore IV® Multimedia Co-Processor	Dual Core VideoCore IV® Multimedia Co-Processor	ARM Mali T764 @ 600 MHz	Mali T720	Mali-400 MP2	Mali-450 MP3 @ 750 MHz	ARM Mali-400	ARM Mali-400 MP2 GPU dual-core		
RAM	1 GB DDR2	512 MB	512 MB	2 GB	2 GB - 1 GB	2 GB	2 GB	512 MB (DDR3)	1 GB	2 KB	
Onboard storage					8 GB EMMC (optional)	16 GB EMMC Flash	8 ~ 64GB optional	4 GB EMMC			
Ethernet (LAN, RJ45)	✓ 10/100	– via USB	✗	✓ 10/100/1000	✓ 10/100/1000	✓ Realtek RTL8211E, 10/100/1000 Mbps	✓ 10/100/1000	✗	✓ 10/100/1000		
USB	✓ 4x USB2.0 + micro OTG	✓ micro + micro OTG		✓ 4x USB2.0	✓ 4x USB3.0 + 1x USB2.0 + mirco OTG	✓ 4 + OTG	✓ 4x USB2.0 + micro OTG	✓ 1x USB2.0 + micro OTG	✓ 2x USB2.0 + micro OTG		
SATA Ports	✗	✗	✗	✗	✗	✓ 1xSATA 2.0	✗	✗	✓	✗	✗
HDMI port	✓	✓ mini	✓ mini	✓ 2.0	✓ 2.0a	✓ 1	✓ 2.0	– via adapter	✓	✗	✗
Wi-Fi	✓ 802.11n	✗	✓ 802.11n	✓ 802.11n	✓ 802.11 a/b/g/n/ac	✓ 2.4 GHz 802.11 b/g/n	✗	✓ 802.11 b/g/n	✗		
Bluetooth®	✓ 4.1 LE	✗	✓ 4.1	✓ 4.0	✓ 5.0	✗	✗	✓ 4.0	✗		
RTC	– optional	✗	✗	✗	✗		– optional		✗		
Additional											
Release date	2016 Feb 29	2015 Nov 30	2017 Feb 28	2017 Jan 23	2019		2016	2016	2014 Mar 1		

Personal favourites

Features

- **ESP32-based**, built-in **Bluetooth, WiFi**
- **16M** Flash, **8M** PSRAM

Arduino
MicroPython
54x54x16mm

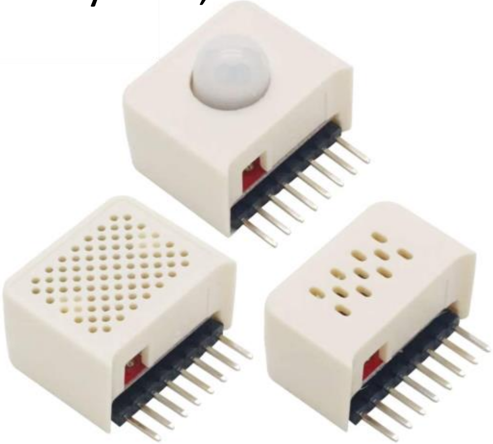
BATTERY: 3.7V/390mAh
2"LCD 320x240@ILI9342C
MICROPHONE@SPM1423
CAP.TOUCH/VIBRATION MOTOR

Personal favourites

Features

ESP32-based: 240MHz dual-core, 600 DMIPS, 520KB SRAM, 4MB Flash Memory, Wi-Fi, Bluetooth
Built-in 6-Axis IMU
Red LED
IR transmitter
Microphone
Buttons,
LCD (0.96 inch)
Built-in Lipo Battery
Extendable Socket
Wearable & Wall-mounted
Development Platform UIFlow, MicroPython, Arduino

Cost: $9.95



Personal favourites

M5StickV K210 AI Camera

Dual-Core 64-bit RISC-V RV64IMAFDC (RV64GC) CPU / 400Mhz(Normal)/ 8MB SRAM / 16MB Flash
Dual Independent Double Precision FPU
Neural Network Processor(KPU) / 0.8Tops

Applications

Face recognition/detection
Object detection/classification
Obtaining size and coordinates of the target in real-time
Obtaining the type of detected target in real-time
Shape recognition
Video/Display
Game simulator

Cost: $29.90

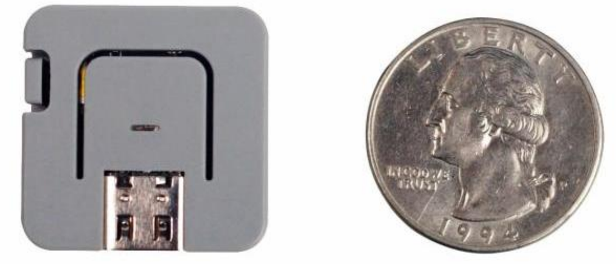

M5STACK


CHALLENGE!
NO
Flying-Demo-Code
VL53L0X
MPU6886
ATOM
LITE
(include)
BMP280
ESP32
200mAh
/25C
Charger
SCL:21
SDA:25
PWM1:22
PWM2:19
PWM3:23
PWM4:33
I2C
ESP32
BMP280
200MAh
ToF VL53L0X
6DOF MPU6886


5x5 RGB
LED(G27)
M5STACK
MPU6886
inside
M2-SCREW
HOLE
Ext.Pin
IR-LED
Reset
PH2.0-4P
Ext.Pin
@2.54mm
USB-C
24x24x14mm
ESP32-PICO
Arduino
UI-FLOW
MicroPython
MATRIX


M5STACK


RGB
29
35



Personal favourites

lopy4

PyGo 2

pycom products

- **ESP32 SoC**
- **LTE-M, LoRa, WiFi and Bluetooth**
- **Range: Up to 40km**

PyGo2

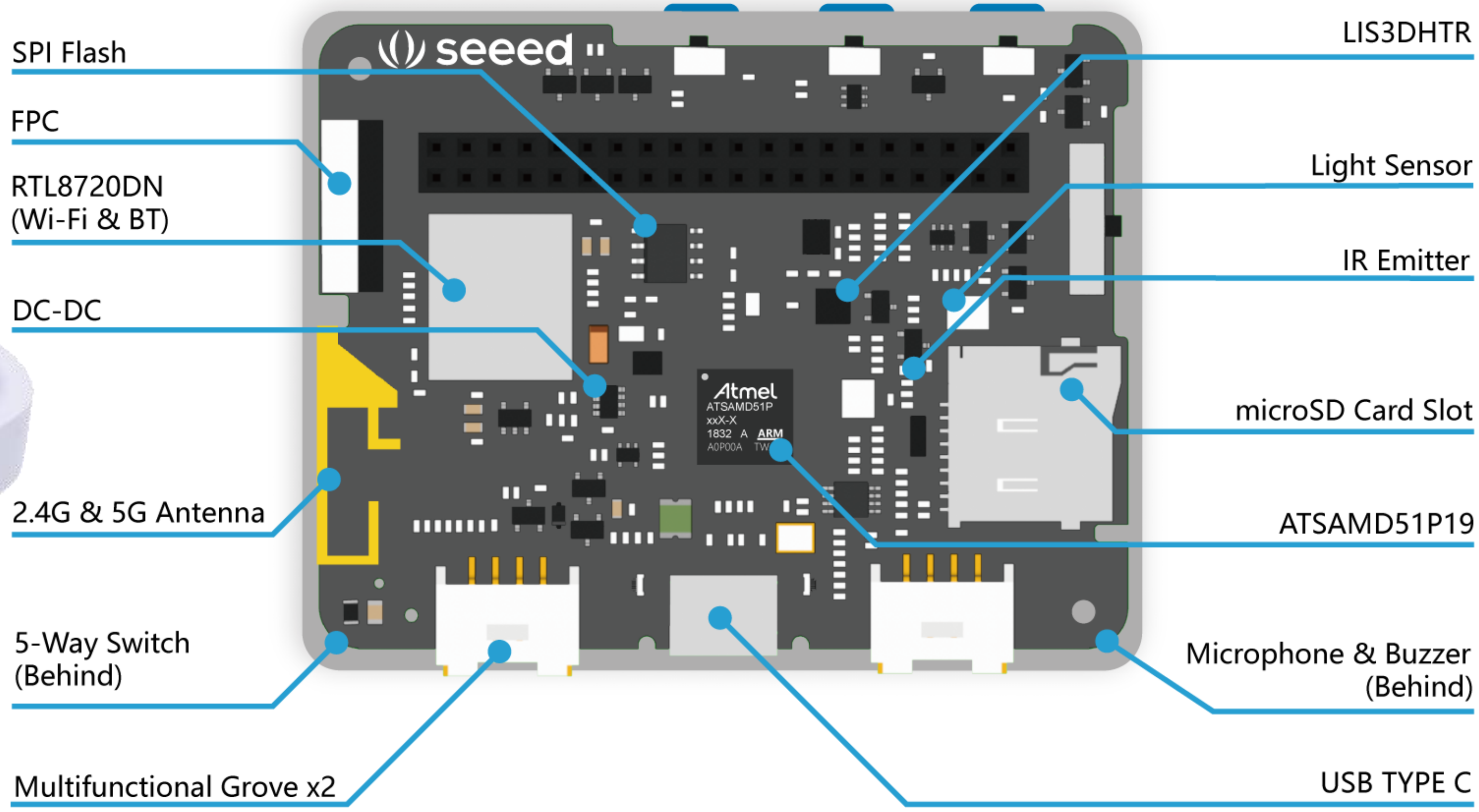
- OLED (Piezo touch screen)
- GPS
- Accelerometer
- State of the art antennas
- LiPo battery
- QI wireless charging
- 6 exposed pins (2 charging/4 universal in/out)

Cost: $29.90

Personal favourites

Wio Terminal: ATSAMD51 Core with Realtek RTL8720DN BLE 5.0 & Wi-Fi 2.4G/5G Dev Board

Cost: $29.90



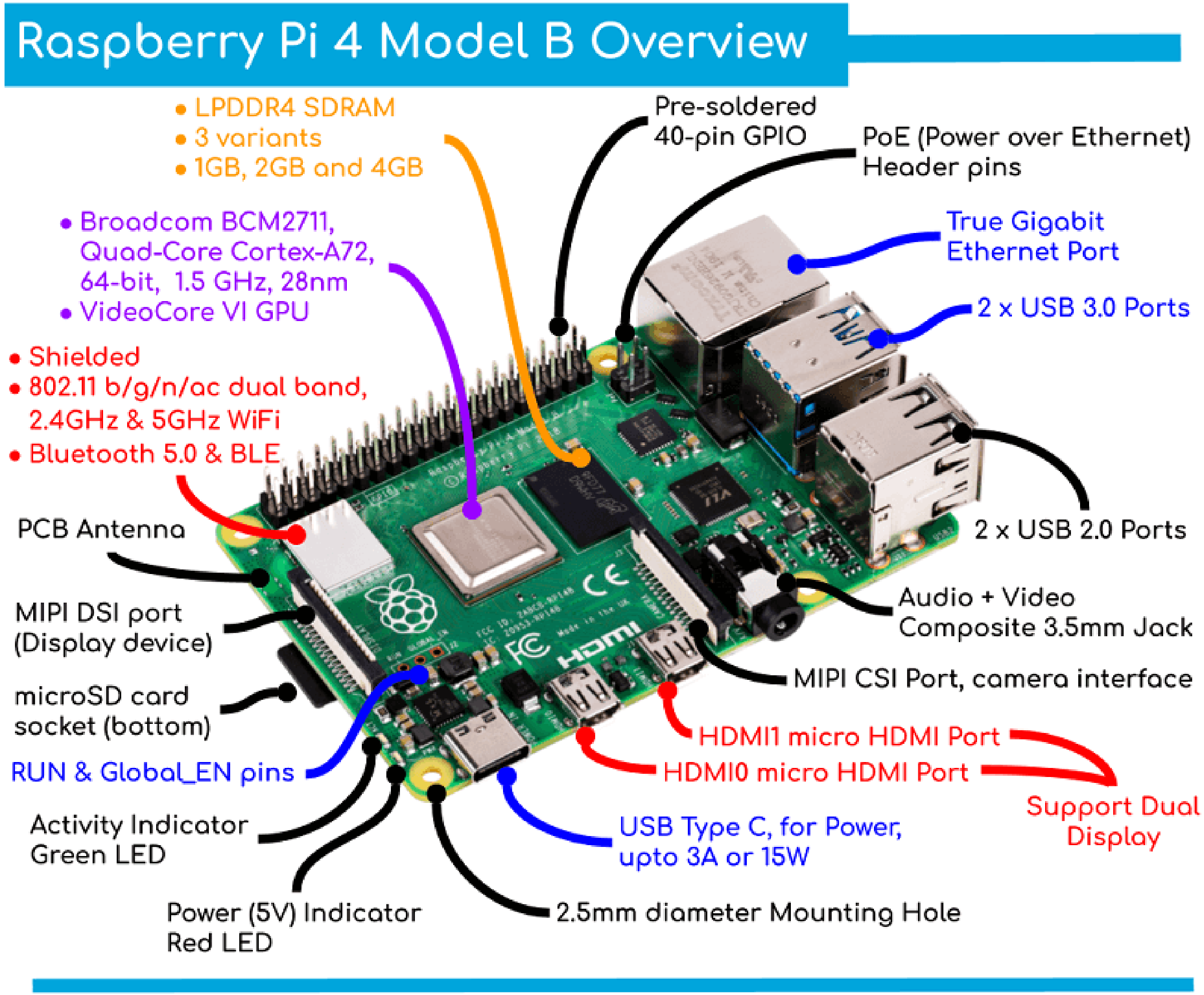
Personal favourites

Sipeed Maix Amigo - All-in-One AIoT Development Platform

Rich Peripherals
RV64GC RISC-V 64-bit Dual-Core CPU for Powerful AI Applications
Computing Power up to 1TOPS with dual cameras for Heavy Machine Vision Applications
Built-in FPU, KPU, FFT Hardware Acceleration Units
Built-in APU for High-Quality Audio Processing
3.5-inch capacitive touch screen for better user interaction
Supports SPMOD and Grove modules to expand your projects

Cost: $39.00

Personal favourites: Heavy duty



Cost: RM180-350

Powering the IoT system

- The size of an IoT device can range from tiny to very large.
- It might perform a single, simple function, or have complex on-board intelligence.
- It may transfer byte-sized data over short range radio-frequency identification (RFID).
- Or, it may transfer high bandwidth streams of data over long distance cellular.
- The IoT device may be in a fixed or varying location, and it may or may not be easy to access.

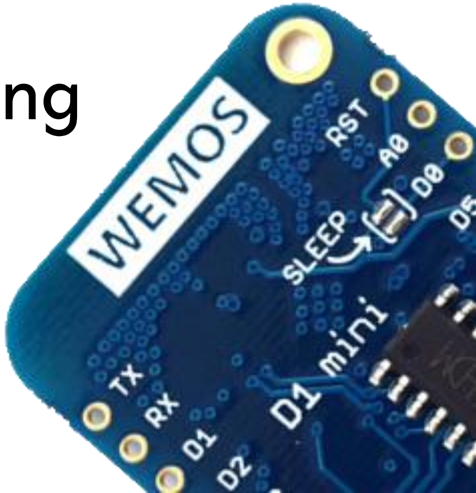
Powering the IoT system

- Across the entire IoT system, there may be more than one power solution.

Types of **Power** Sources

Extending Device Battery Life

- Everything from the microcontroller to sensors to wireless radios use energy
- Choose a correct "duty cycle" based on your application
  - You don't need to measure room temperature every second
  - Accelerometer doesn't need to make 100 measurements per second
  - Fitness tracker can go to "sleep" mode at night (or when user is not active)
- Often, radio transmission is the most power consuming
  - Add memory to your design.
  - Store sensor data locally to transmit in batches.

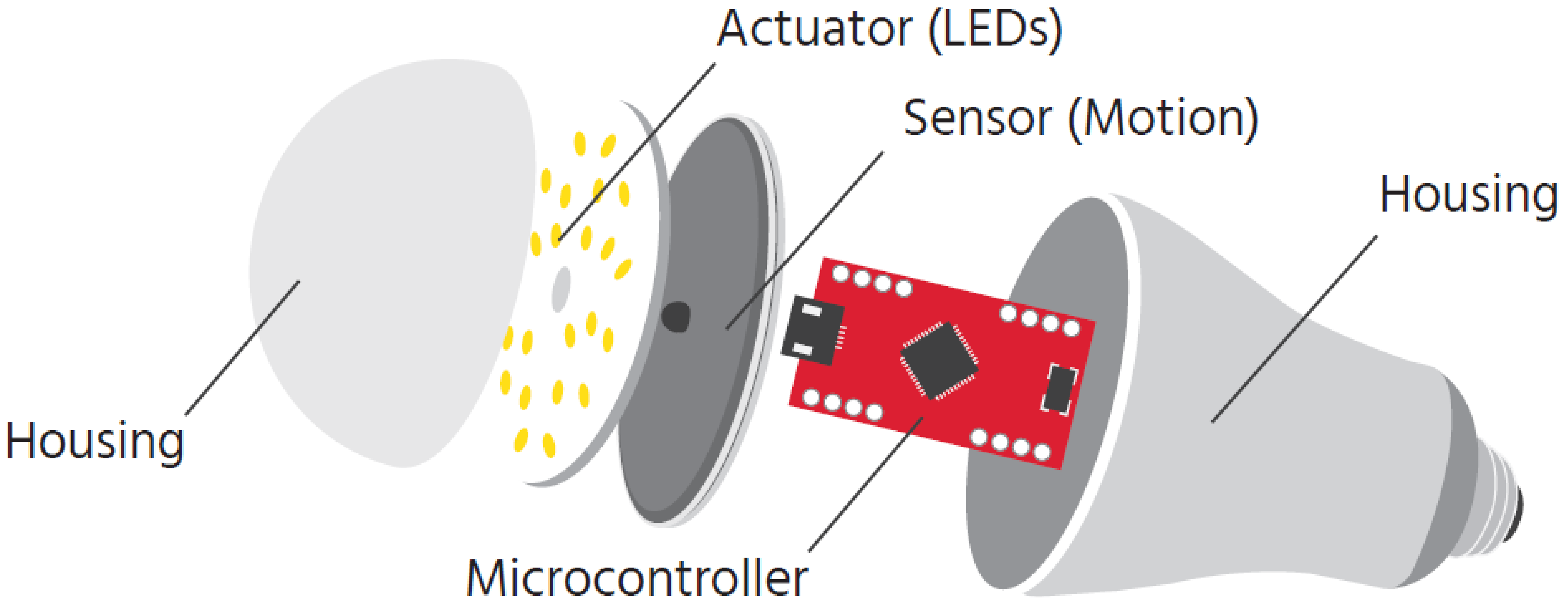


Extending Device Battery Life

- Consider what features are absolutely necessary for your product
  - cut out non-critical features
  - replace with low power alternatives (monochromatic LCD instead of full colour display)

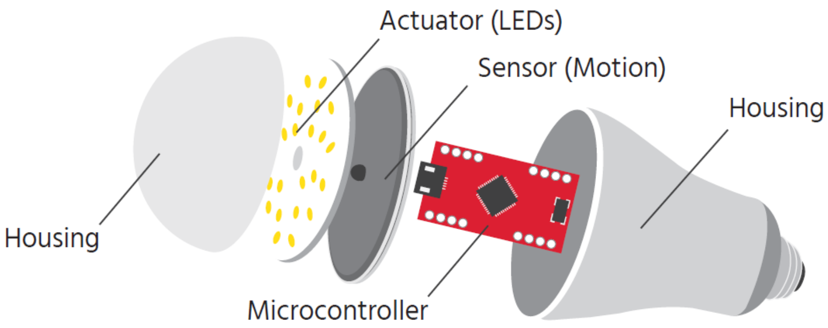
- To summarize:
  - First, narrow down your list of features to only practical, must-haves.
  - Second, closely assess your power budget.
  - Third, weigh your must-have needs against your power budget

Physical Things

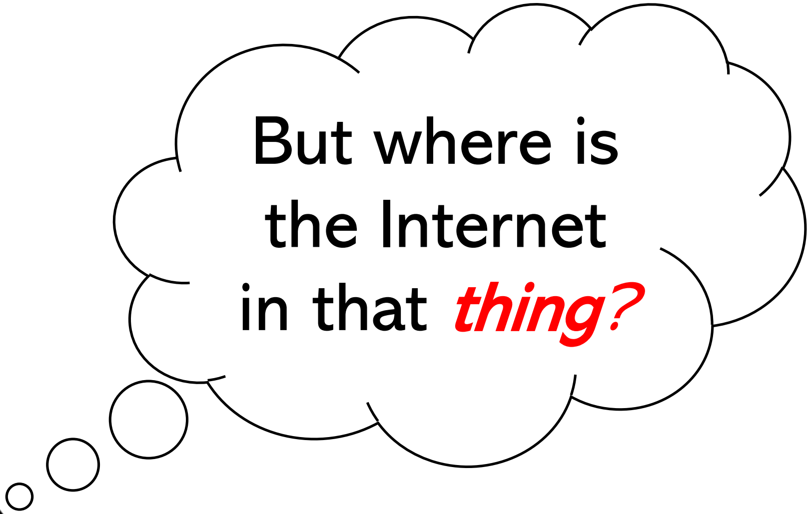


Anatomy of a **Thing**

Physical Things



Anatomy of a **Thing**



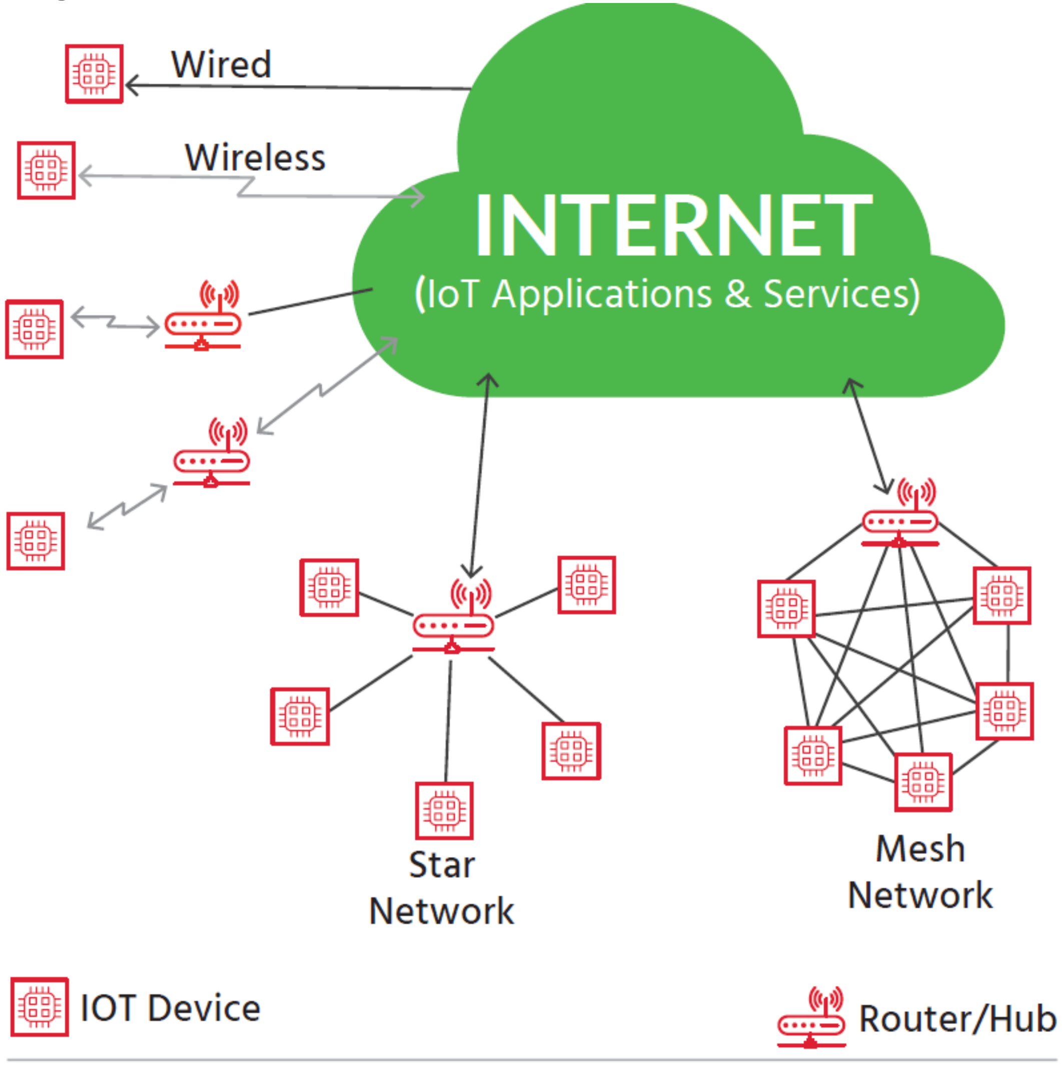
In IoT systems sensors and actuators are connected through the Internet

COMMUNICATION

Connectivity Solutions

- Connectivity can be thing-to-thing, thing-to-server, server-to-server
- Connectivity options for IoT systems:
  - Wired direct (Ethernet cable)
  - Wireless direct (Wi-Fi, 3G/4G, NB-IOT)
  - Wireless local, Wired Internet Connection
  - Star network
  - Mesh network

Connectivity Solutions



Types of **Node Architectures**

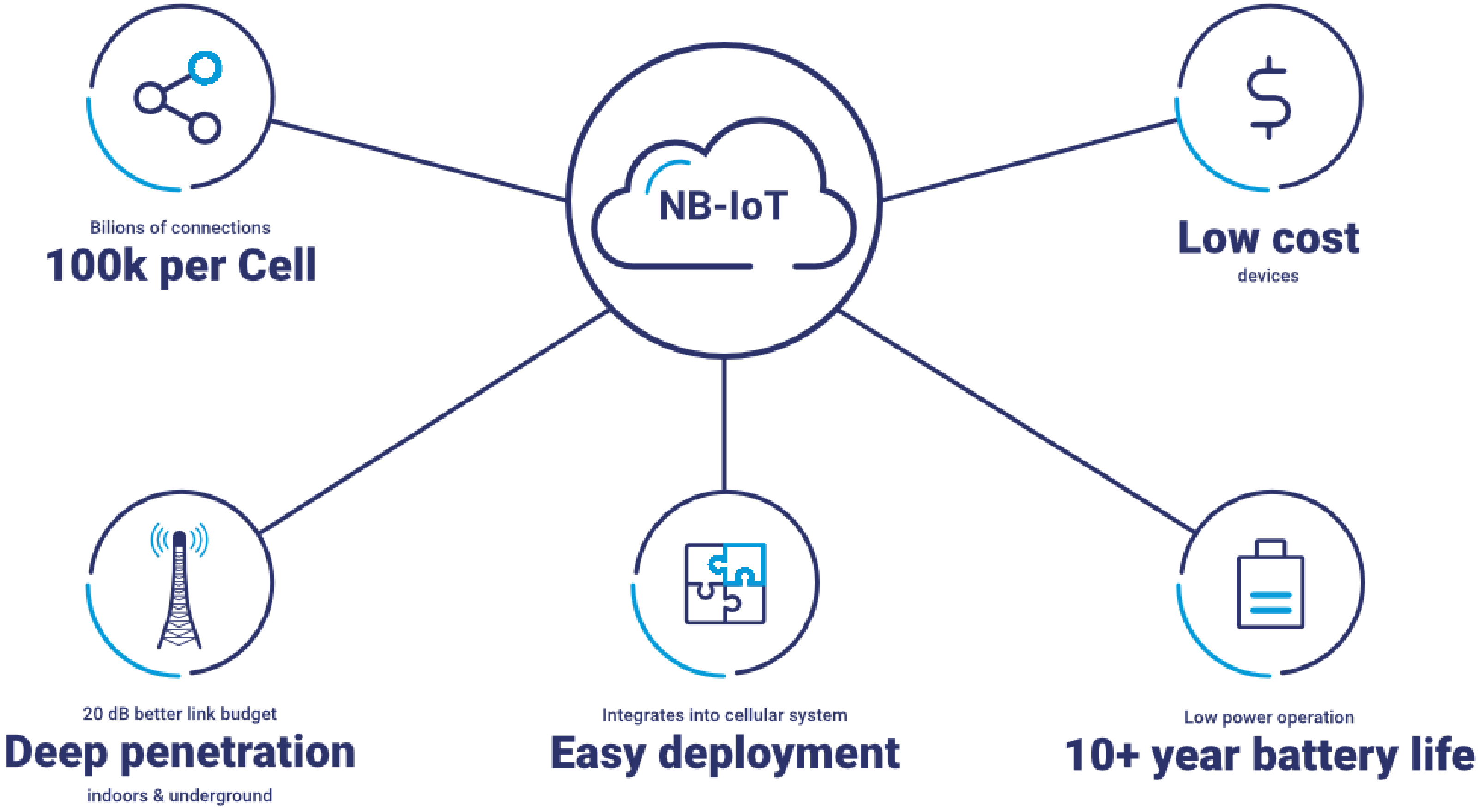
What is the best Wireless solution?

- There isn't one!
- Choose the best depending on the design constraints of the IoT system:
  - Operating environment (outdoor, indoor, far away lands, deserts etc)
  - Device size (may affect antenna and battery size)
  - Cost (affects everything)
  - Data (amount, frequency)
  - Serviceablity (life cycle, maintenance)
  - Power (if main power is unavailable, becomes a serious constraint)
  - On-board vs. remote data processing
  - Simplex/Duplex (one way or two-way data transmission)
  - Security (very serious issue if ignored)

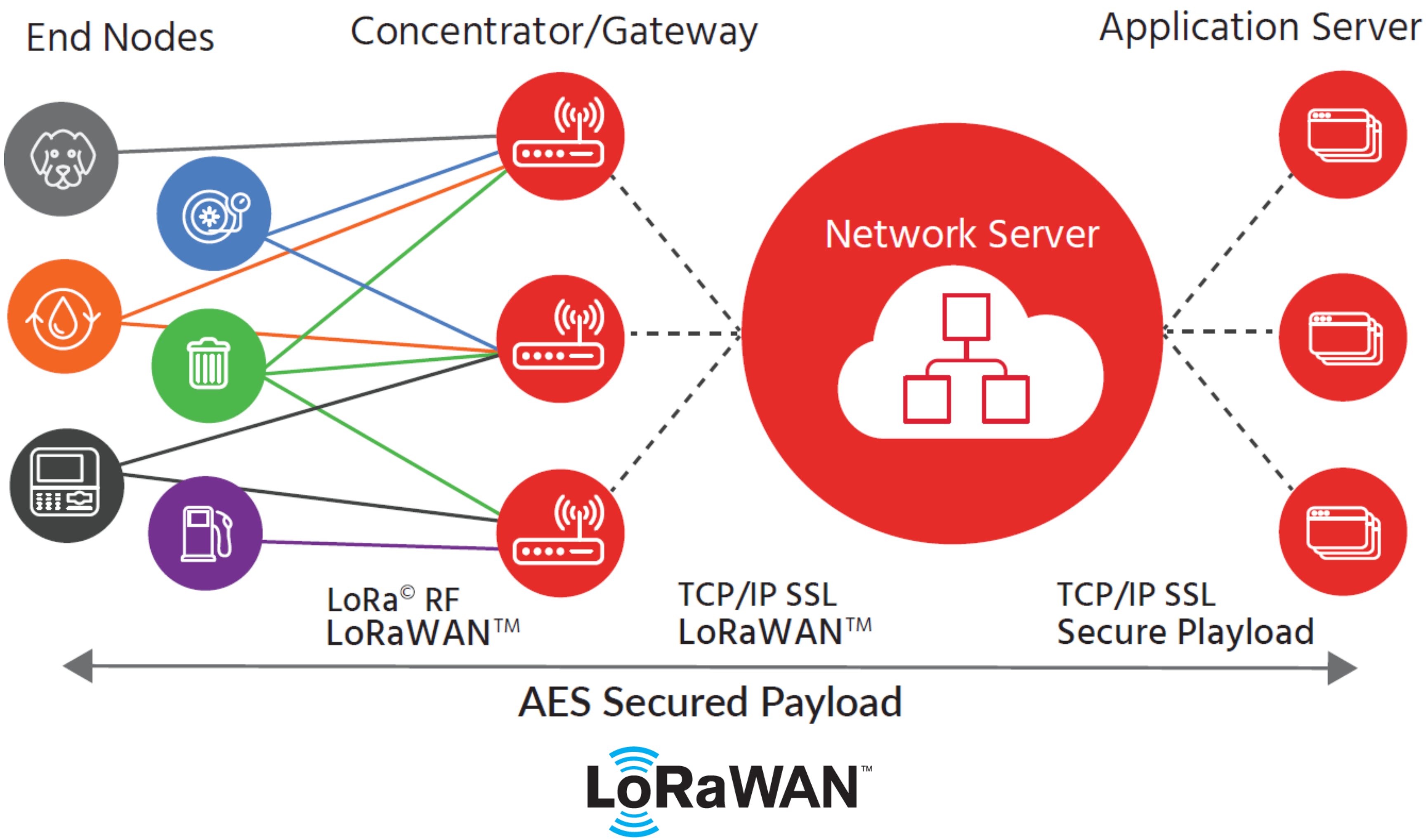
Cellular (GSM/3G/4G)

- Expensive
- Designed for voice and high data throughput/low latency communication (opposite of most IoT systems)
- Difficult to customize protocols for your applications
- The cellular device certification is time consuming and expensive
- Not suitable for difficult radio environments
- High power consumption

Low Power Wide Area Networks LPWAN



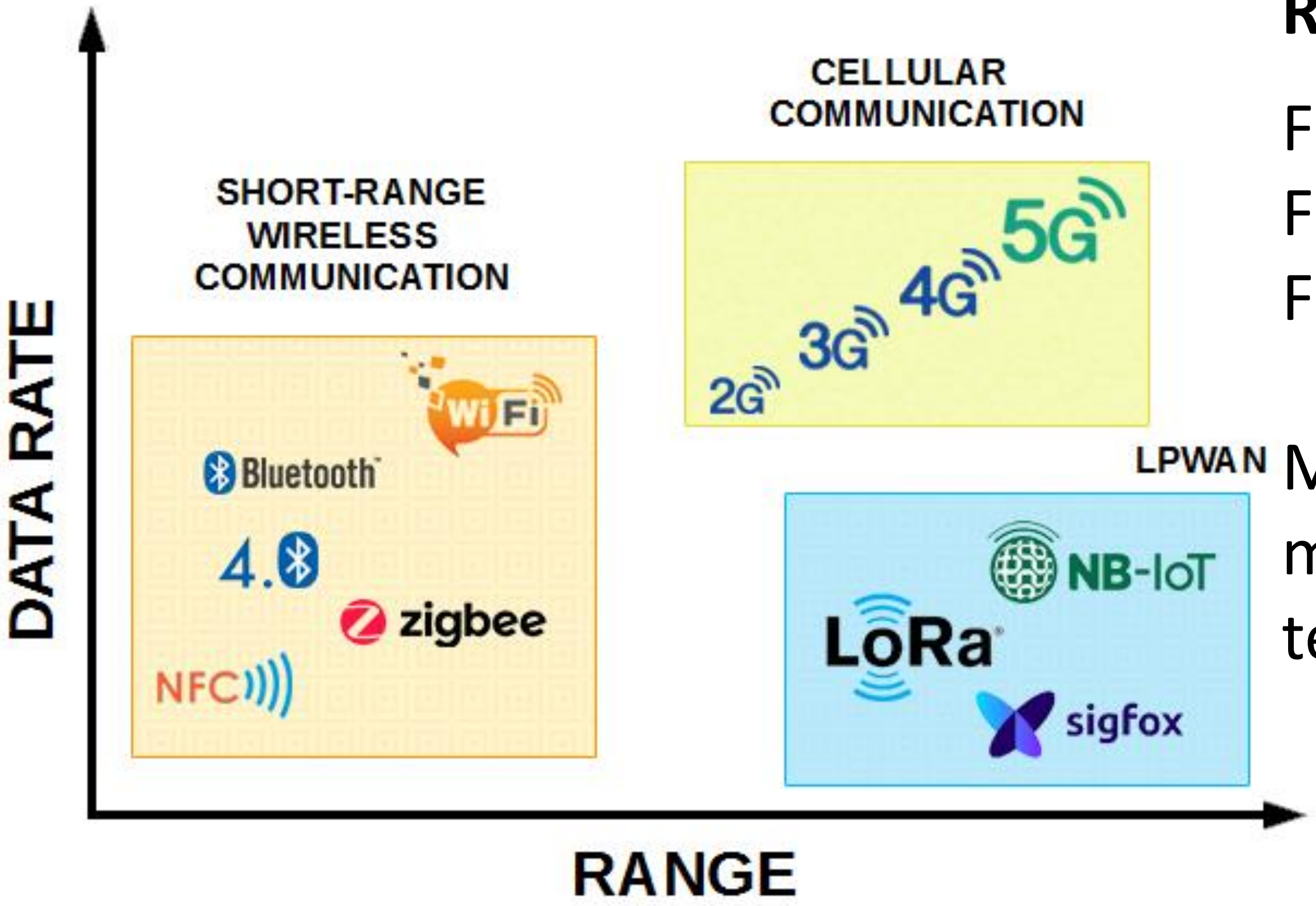
Low Power Wide Area Networks LPWAN



Short to Medium Range Solutions

Variable	Wi-Fi	Z-Wave	ZigBee	Thread	BLE
Year first launched in Market	1997	2003	2003	2015	2010
PHY/MAC Standard	IEEE 802.11.1	ITU-T G.9959	IEEE 802.15.4	IEEE 802.15.4	IEEE 802.15.1
Frequency Band	2.4 GHz	900 MHz*	2.4 GHz	2.4 GHz	2.4 GHz
Nominal Range (0 dBm)	100 m	30 – 100 m	10 – 100 m	10 – 100 m	30 m
Maximum Data Rate	54 Mbit/s	40-100 kbit/s	250 kbit/s	250 kbit/s	1 Mbit/s
Topology	Star	Mesh	Mesh	Mesh	Scatternet
Power Usage	High	Low	Low	Low	Low
Alliance	Wi-Fi Alliance	Z-Wave Alliance	ZigBee Alliance	Thread Group	Bluetooth SIG

IoT Wireless Radio Solutions



Recommended:

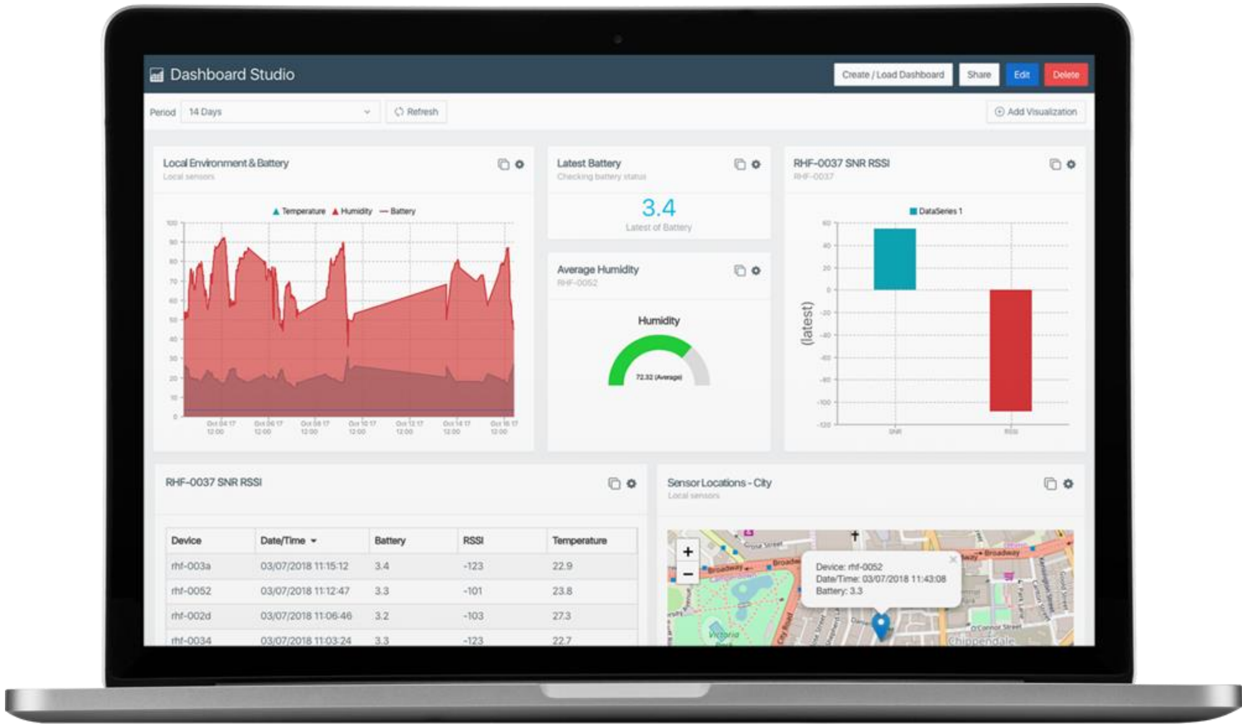
For short range: **Bluetooth**

For local area: **Wi-Fi**

For long range: **LoRa**

Most IoT systems combine multiple communication technologies

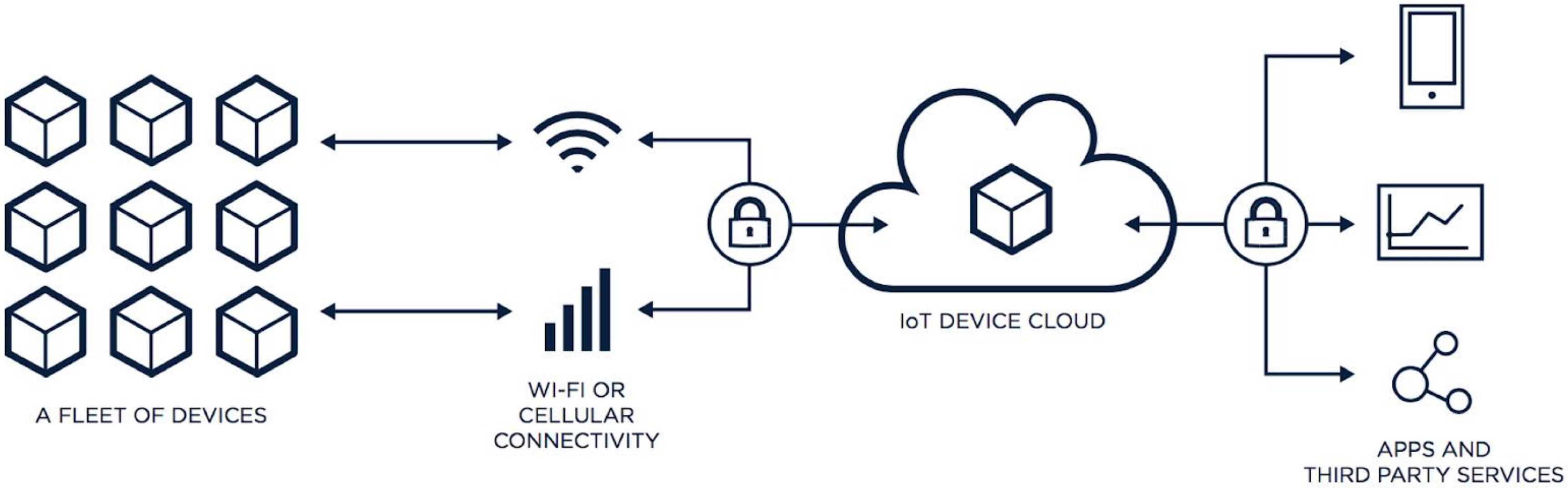
SOFTWARE



Dashboard Studio
Create / Load Dashboard
Share
Edit
Delete
Period
14 Days
Refresh
Add Visualization
Local Environment & Battery
Latest Battery
3.4
RHF-0037 SNR RSSI
Average Humidity
Humidity
RHF-0037 SNR RSSI
Sensor Locations - City
Device
Date/Time
Battery
RSSI
Temperature

Software for IoT

- Microprocessors have limited data ingestion, storage, and processing capabilities
- Connecting the computer-like devices to the internet allows us to utilize remote computing resources, aka “The Cloud”
  - No more size, location, power or other constraints

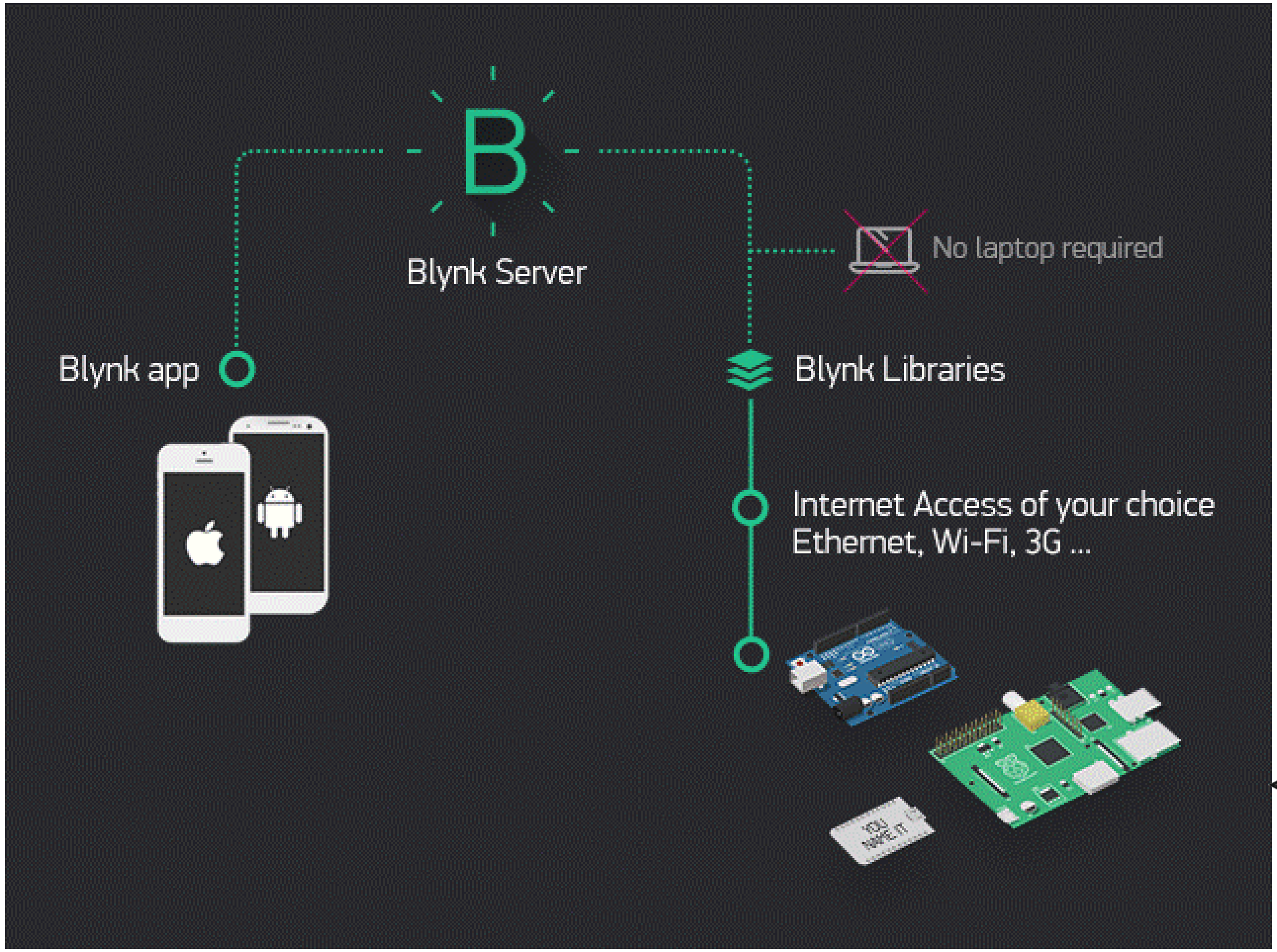


How to choose a cloud platform?

Understand your system requirements

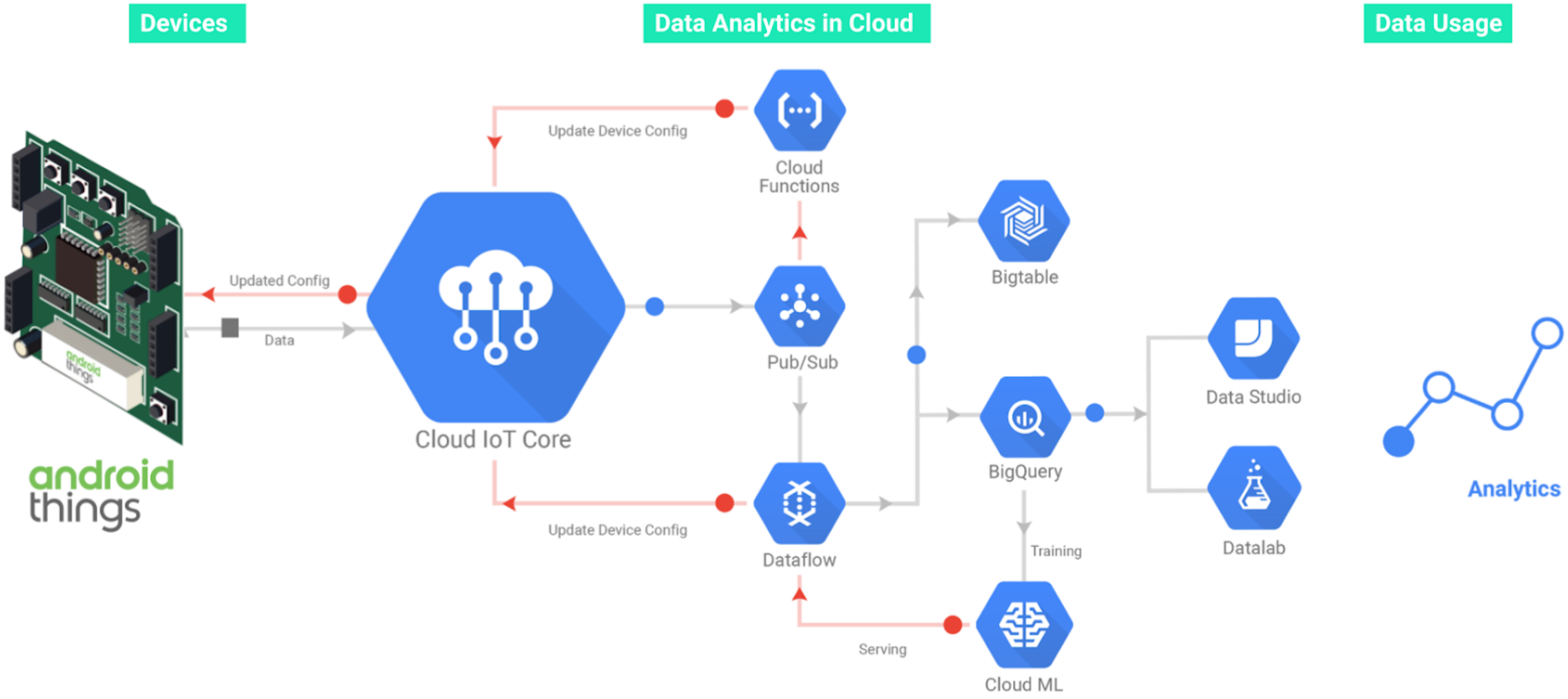
- Horizontal scale, i.e., the number of devices you need to support
- Vertical scale, i.e., the volume and velocity of data you will need to simultaneously process
- Communication protocols you will need to support
- User experience, i.e., UI capabilities and presentation, accessibility of data (API, Web, Mobile)
- Integration with proprietary systems and data sources
- Integration with public API based data services
- DevOps and cloud options, where will it be hosted and who will support and maintain the system

For IoT mobile app: Blynk



For monitoring and R&D: Thingspeak

For deployment: Google IoT Cloud



OPERATIONS

Operations

- Developing an IoT solutions is half of the battle

- Once deployed and IoT system requires a diversified set of technologies to support the system:
  - Datacenter Infrastructure
  - Software development and information technology operations
  - Hardware and software support of physical things
  - SECURITY!

IoT system Data challenges

- Storage
  - How long to store the data?
- Privacy
  - Particularly important for sensitive and personal data (healthcare)
- Security
  - Some systems may require stronger encryption and authentication to protect the data (payment systems)

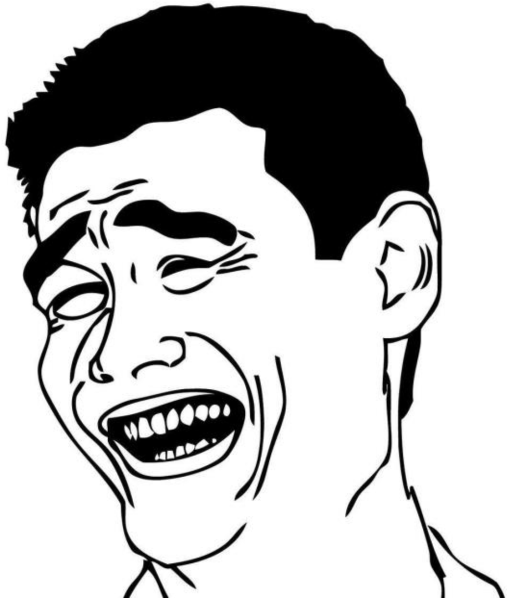
Security

Fitness tracking app Strava gives away location of secret US army bases

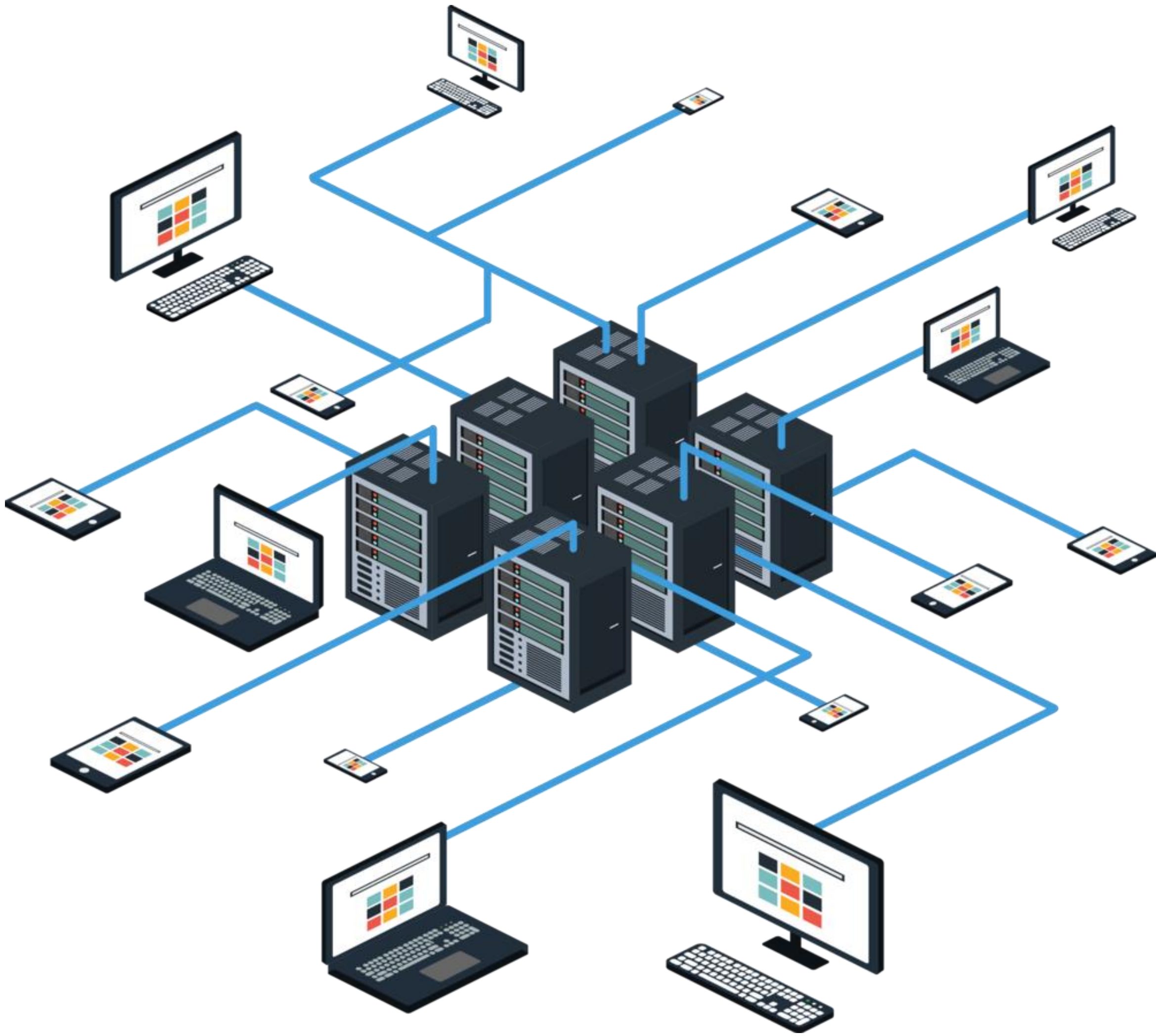
Data about exercise routes shared online by soldiers can be used to pinpoint overseas facilities

- **Latest: Strava suggests military users 'opt out' of heatmap as row deepens**

S** in **IoT** stands for **Security



DATA

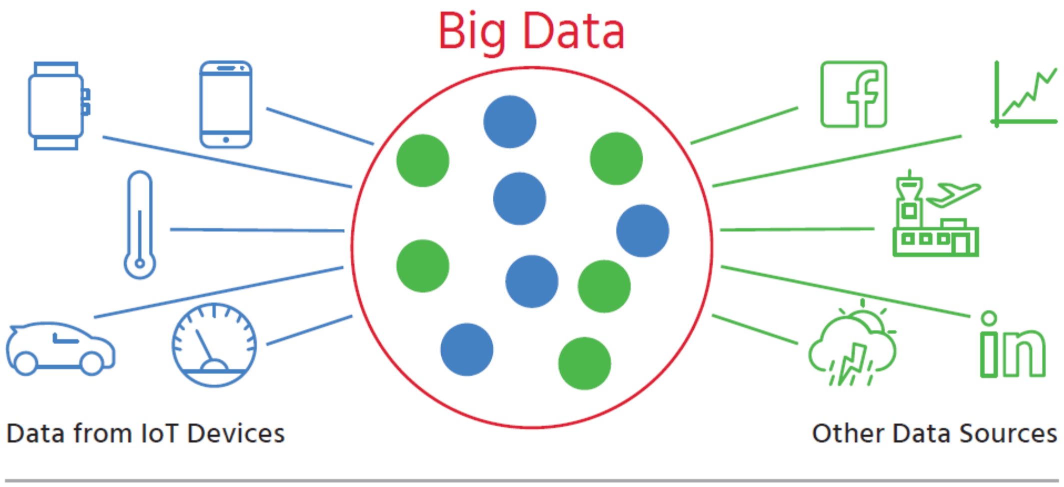


Small Data

- A single sensor generates a small data
- There are many reasons to capture and use small data.
  - For example, a connected refrigerator may employ small data to monitor user habits like opening/closing the door.
  - It could also use small data to automatically adjust temperature to ensure consistent cooling of the food inside.
- Local data is enough to create value in many use cases.

Big Data

- Aggregating data from small sources is how it becomes a Big Data
- We can aggregate our small data from individual, connected devices within an IoT system.
- We can mash that data with data from one or more other IoT systems.
- And mash that data with public data sources such as weather records, stock market prices, and census data.



Big Data Sources

Summary

- IoT is system of systems
- Main components of an IoT system:
  - Physical things
  - Communication channels
  - Software
  - Operation
  - Data

Q&A

- Thank you for your attention!