AtoZ INFOWAY LLP

OpenCorner

Internet of Things

Step Towards Smart Future

Bhavesh Valand
Bhavik Prajapati

AtoZ INFOWAY LLP

AtoZ Infoway LLP is a dynamic IT development company which was established in the year 2000 offering competent technology and strategic business solutions. We always look for new ways to provide solutions and create a better product. Seeing our clients being highly passionate about their project's concept and ideas makes us energized.

We provide full life cycle **Enterprise Software Development**, **Mobile Apps Development**, **Web Development**, **IT Consulting**, **UI/UX Design**, **IoT Development**, **SharePoint**, **HRMS**, **Smart Farming and Transportation Solutions**. With sturdy technical and business analysis teams, we make the most exceptional products even better. Our business development and service teams have the best professionals who can solve any problem in no time and deliver the best solution to our client's queries. Customer contentment with quality and timely services is our key objective.

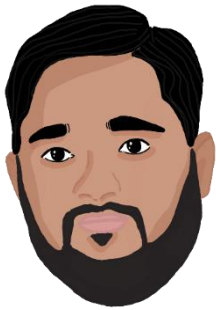
OpenCorner

Learn | Educate | Build | Connect

- Who is OpenCorner?
- Our Mission
- Our Vision

Let’s introduce the Team

Bhavesh Valand



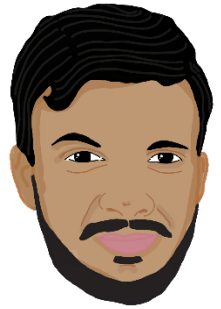
“Digital Marketing head, Project Manager, and team lead.

A pro with 9 years of experience, can take your website to a new level. Master in Google analytics and is a Google AdWords certified.

Bhavesh's SEO skills are so strong, that he may answer your doubts even in deep sleep.

Bhavesh follows and lives up to his statement and commitments with a simple ideology of **One Team One Vision One Mission**.”

Bhavik Prajapati

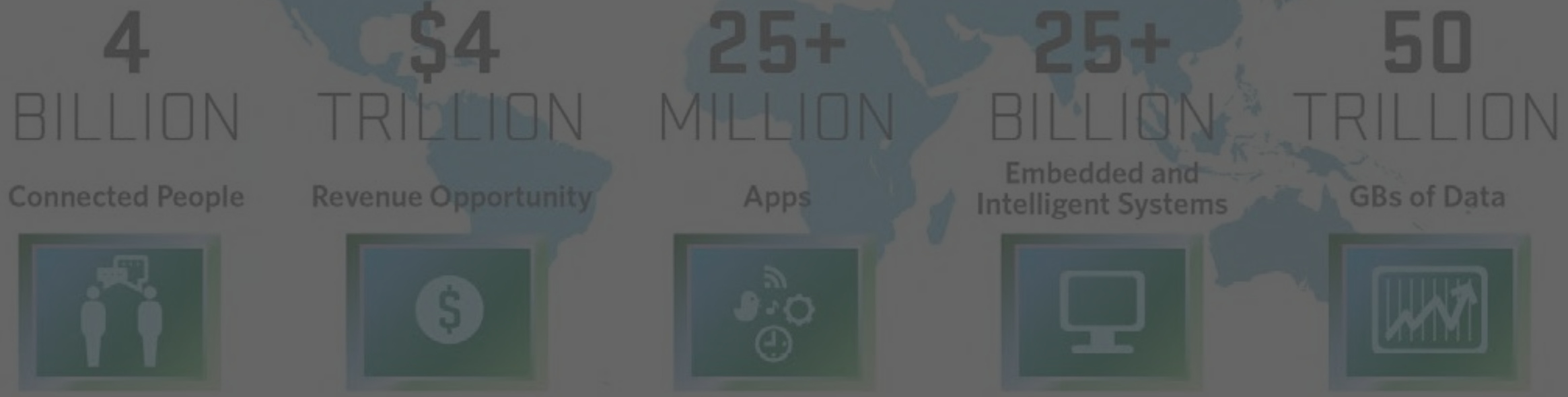


“Bhavik is an IoT Expert and has more over 2.6 years of experience in end to end solutions of IoT.

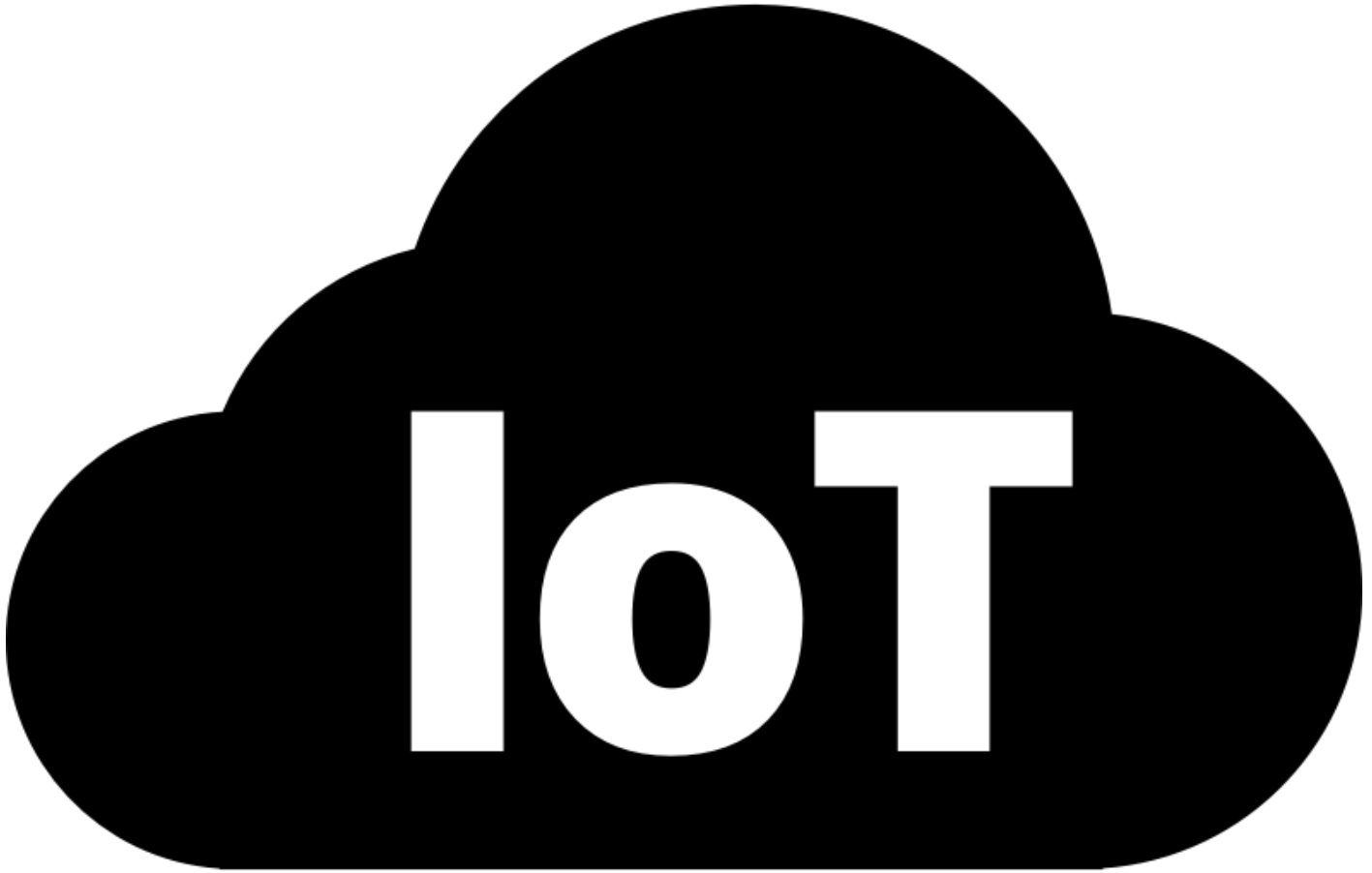
He strives to work in different areas of IoT like Embedded Systems including various MCU's, CPU's, RF Technologies, IoT Protocols, and Security, Cloud Services, Mobile apps thus giving him a clear vision of its implement.

He is here to help young minds to kick themselves to a new level.”

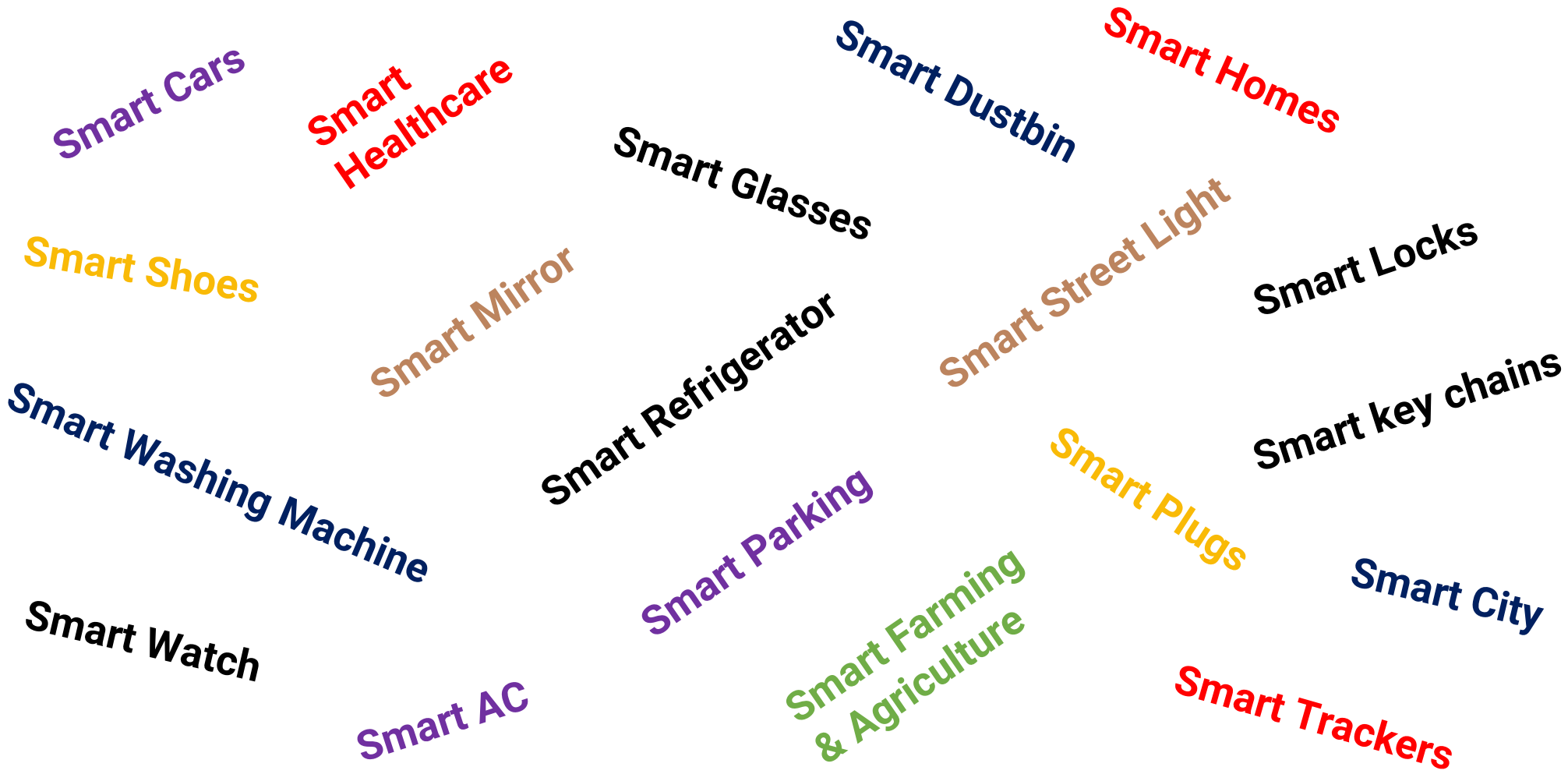
Internet of Things
- Step Towards Smart Future



Introduction To



Smart Things !

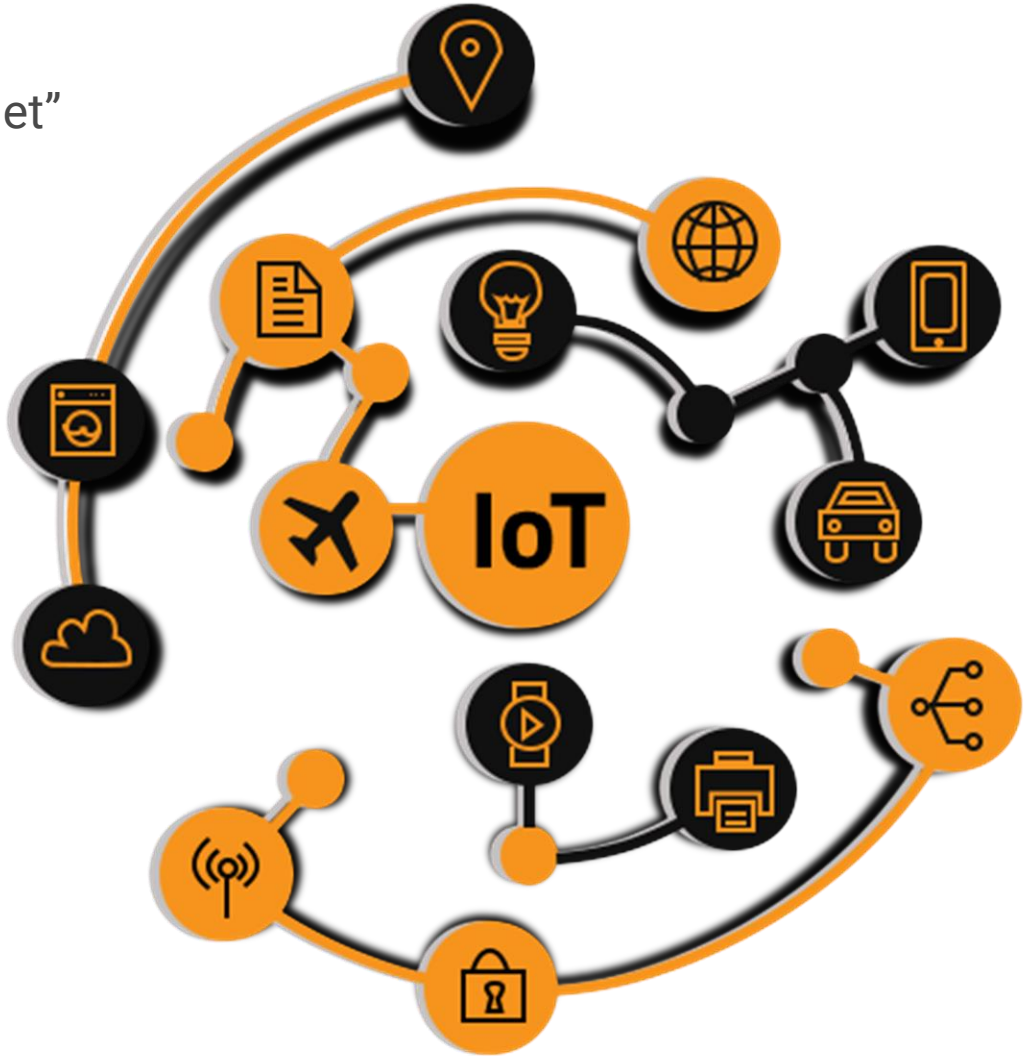


Smart Things !

Img src : https://in.pinterest.com

Internet of Things

“Network of things” or simply “Things connected to the internet”



Img src : romaninfosolutions.com

What is IoT?

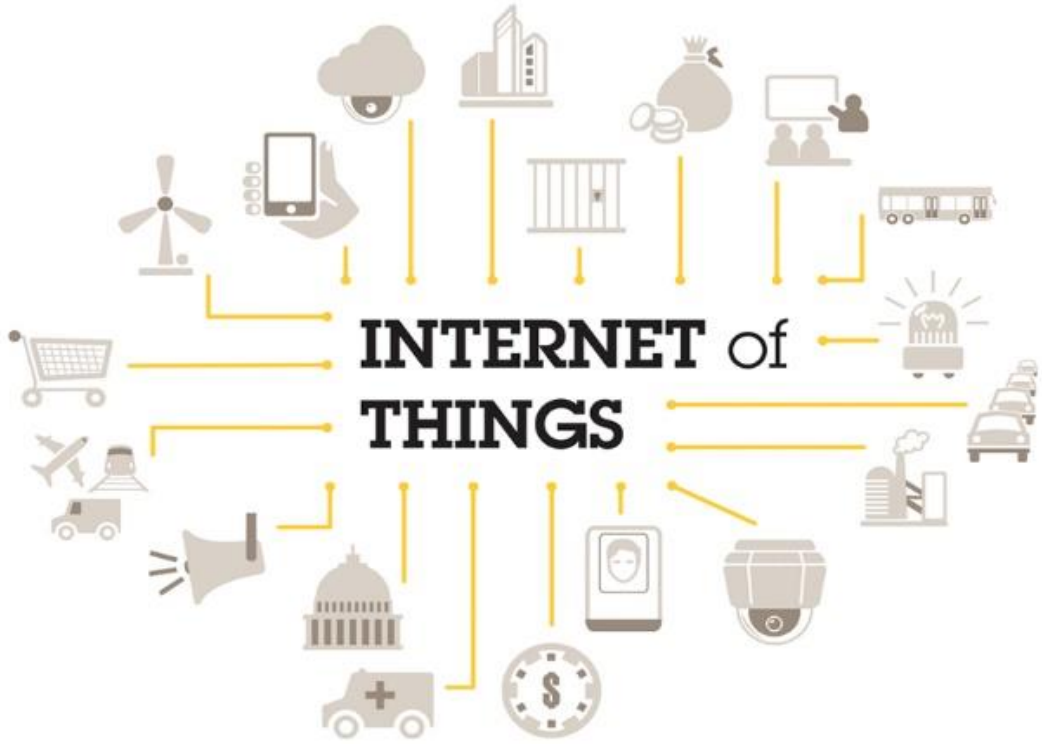
What is IoT?

As the name suggest Inter Connectivity of various things or devices using various network and application layer protocols

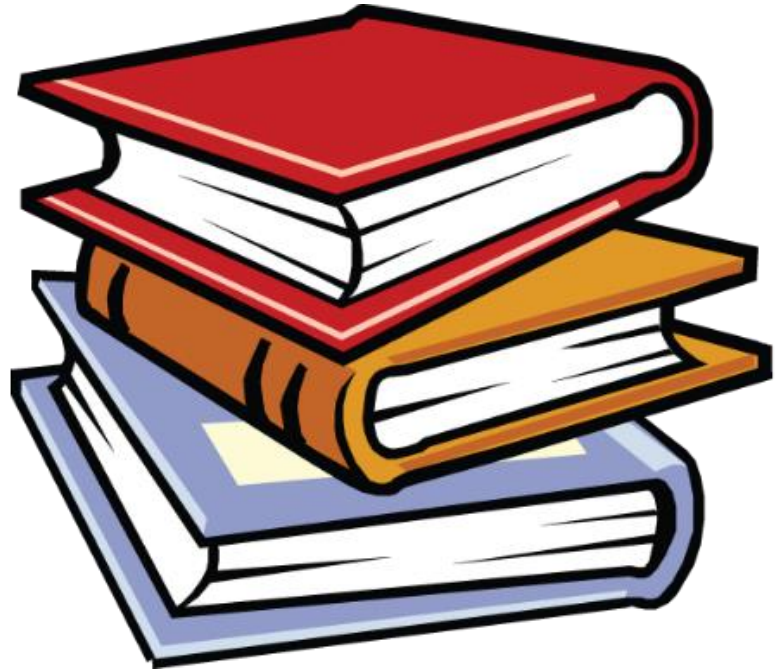
Definition:
The Internet of Things (IoT) is the network of physical objects-devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity-that enables these objects to collect and exchange data.

What is IoT?

A Thing , in the Internet of Things can be anything, it can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low - or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network.



History



History

Wanted to attract management's attention to a new exciting technology called RFID. Because the internet was the hottest new trend in 1999 and because it somehow made sense, he called his presentation "Internet of Things"

Kevin Ashton

Img src :smithsonianmag.com

History

1970 Actual idea of internet of things emerged

Internet connected Toaster is Invented **1990**

2000 LG announces it's first Internet refrigerator plans

"The Internet of Things" in Forbes **2002**

History

2004 — Term is mentioned in The Guardian and Scientific American publication

2008 — First European IoT Conference Held

2009 — The Internet of Things was "Born"

2010 — Google Start Developing Self Driving Car

Why?

Img src : www.istockphoto.com

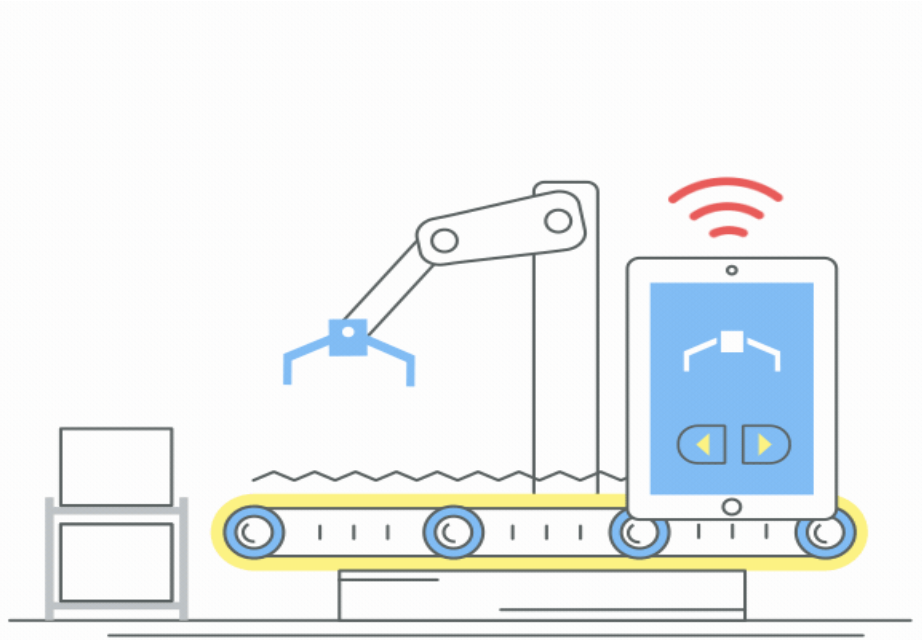
Why?

To control stuffs around us

Img src : gfycat.com/

Why?

To bring Automation



Img src : https://vali.tech/devices/

Why?

To make day to day life easier and faster

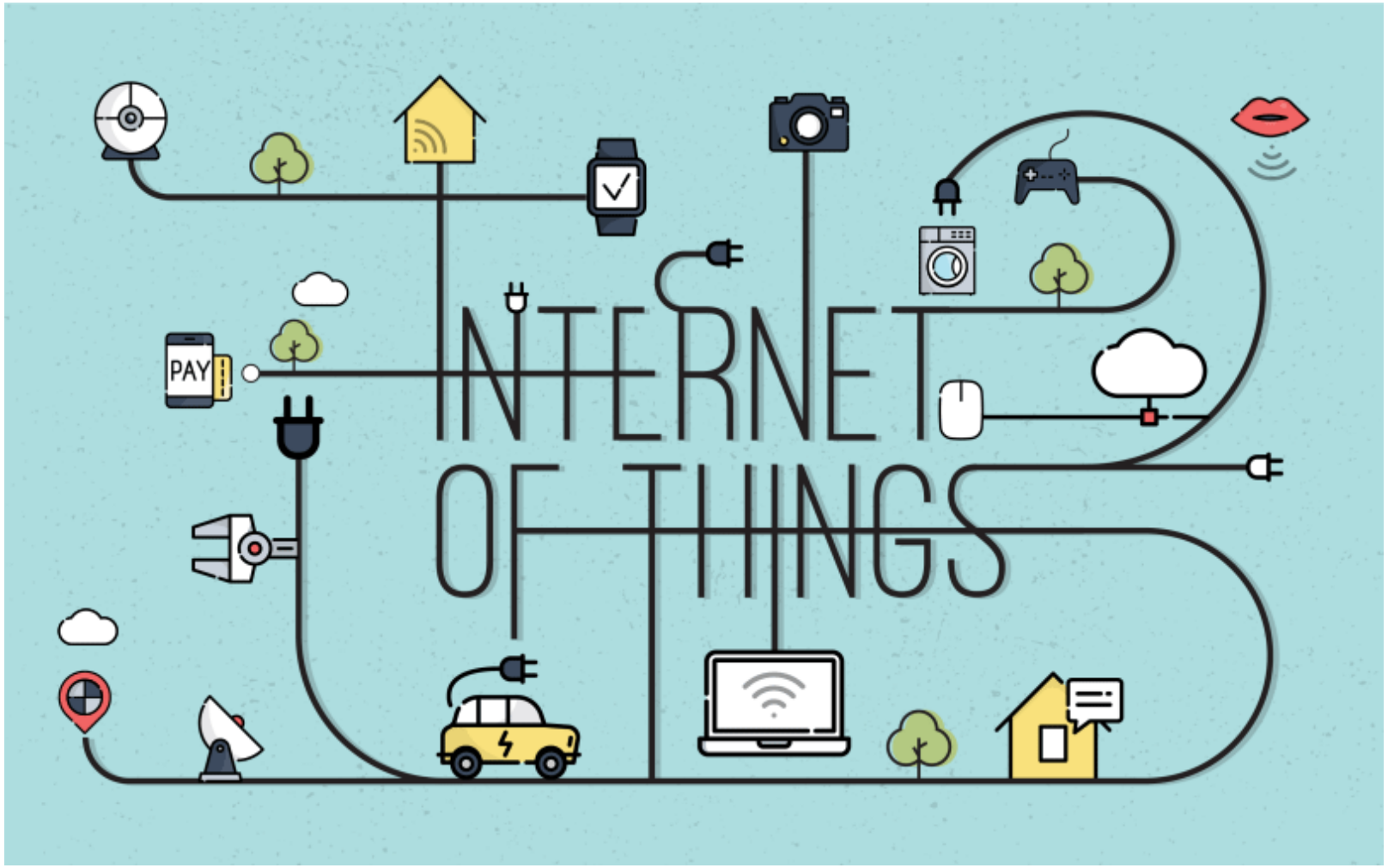
Img src : gfycat.com/

Why?

To save money and time

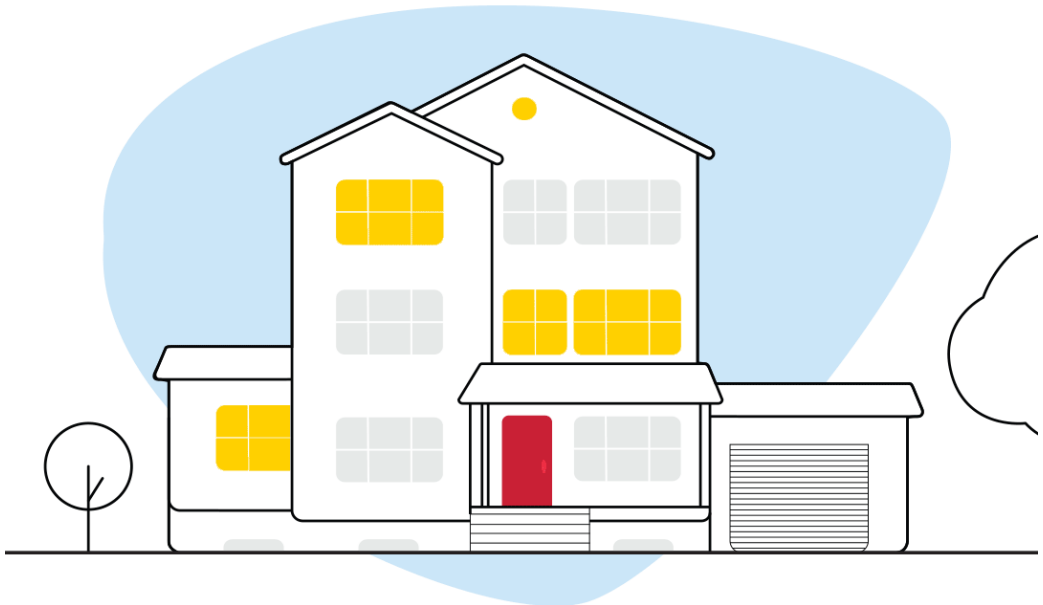
img src : https://clipart.wpblink.com/

Applications



img src : nrschariottechpvtltd

Smart Home



Smart Connected Appliances

Automatic light and temperature controlling

Security and Monitoring

Energy Optimization

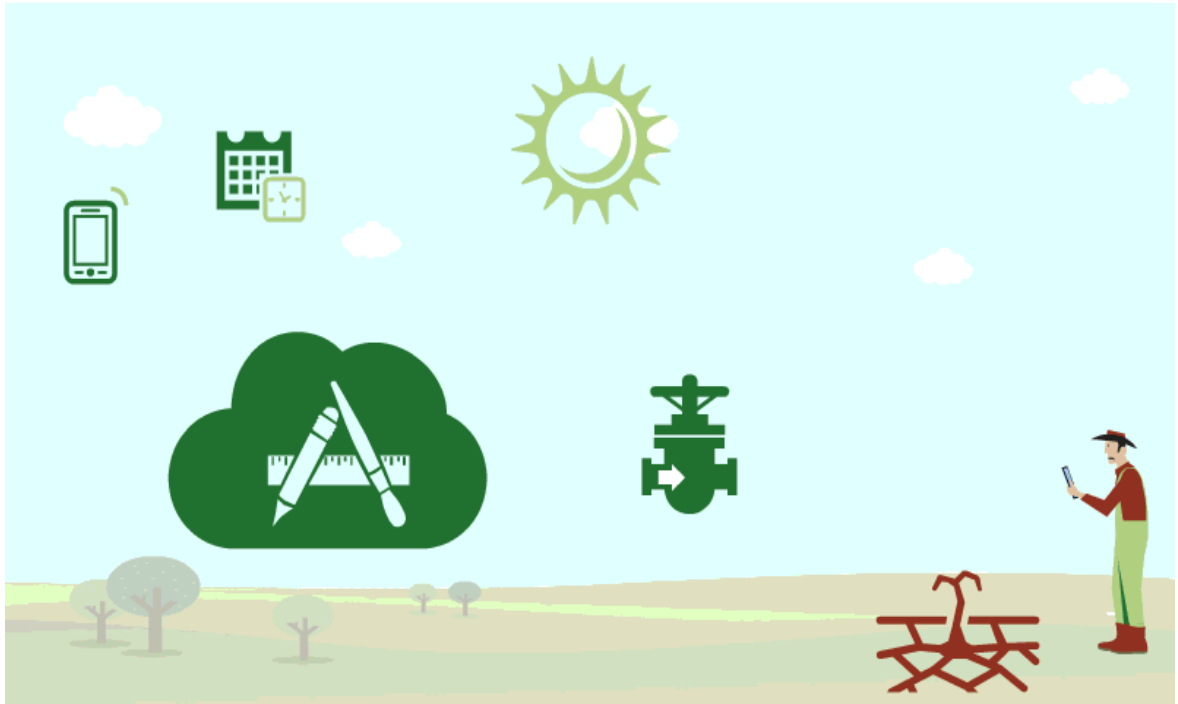
img src :blog.belairdirect.com

Smart City

- Innovative solution to traffic congestion
- More reliable public transportation
- Smart street Lights
- Smart parking
- Smart Waste Management
- Smart Buildings

img src : https://in.pinterest.com

Smart Agriculture



Crop monitoring

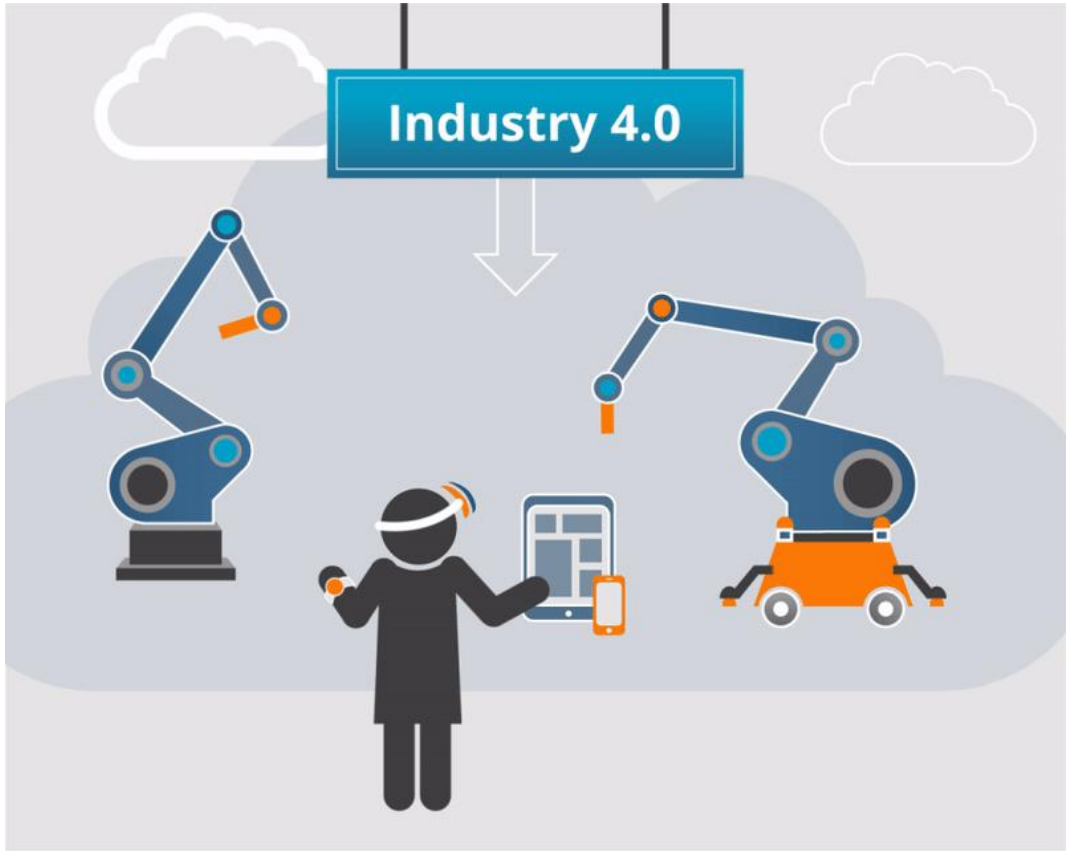
Soil quality monitoring

Smart Irrigation

Cattle management

img src :epointagro.com

Industrial IoT



- Predictive Maintenance
- Machine Monitoring
- Toxic Gases and Air Quality Monitoring
- Indoor Asset Location
- Production Flow Monitoring

img src : lowgif.com

Smart Healthcare

- Remote Patient Monitoring
- Smart Health care devices
- Predictive analysis of Unknown disease
- Hospital Asset Tracking
- Hospital Management

img src : cogniaim.com

Wearables

Devices for Entertainment

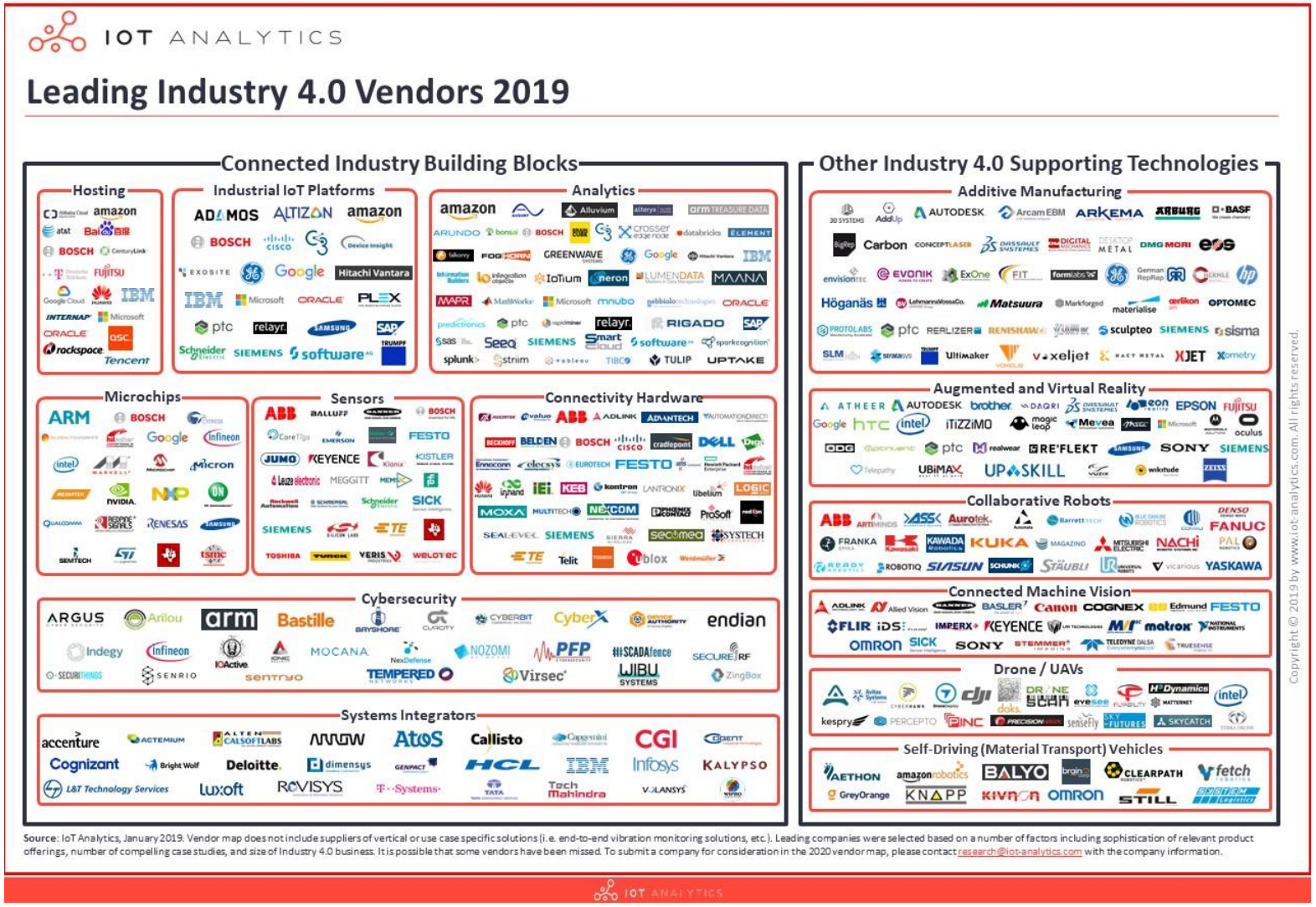
Smart Health care devices

Devices for Tracking

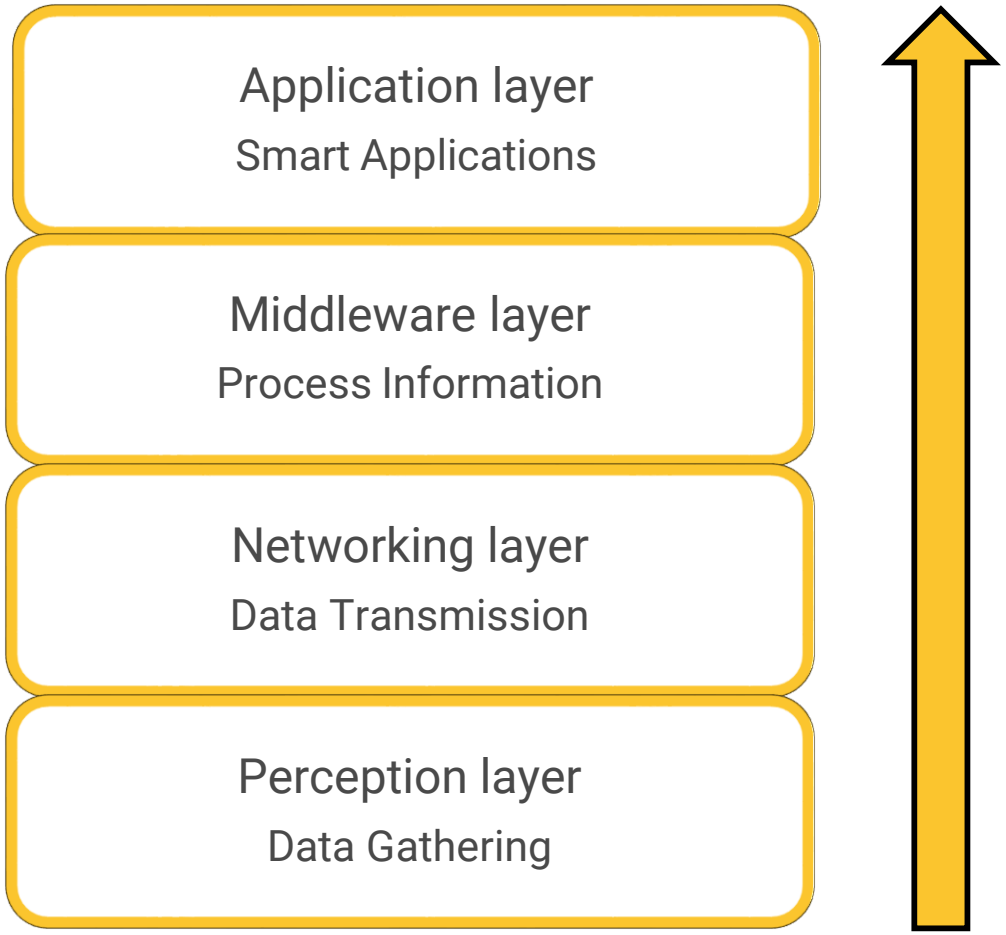
img src : abduzeedo.com

Where we can Implement IoT?

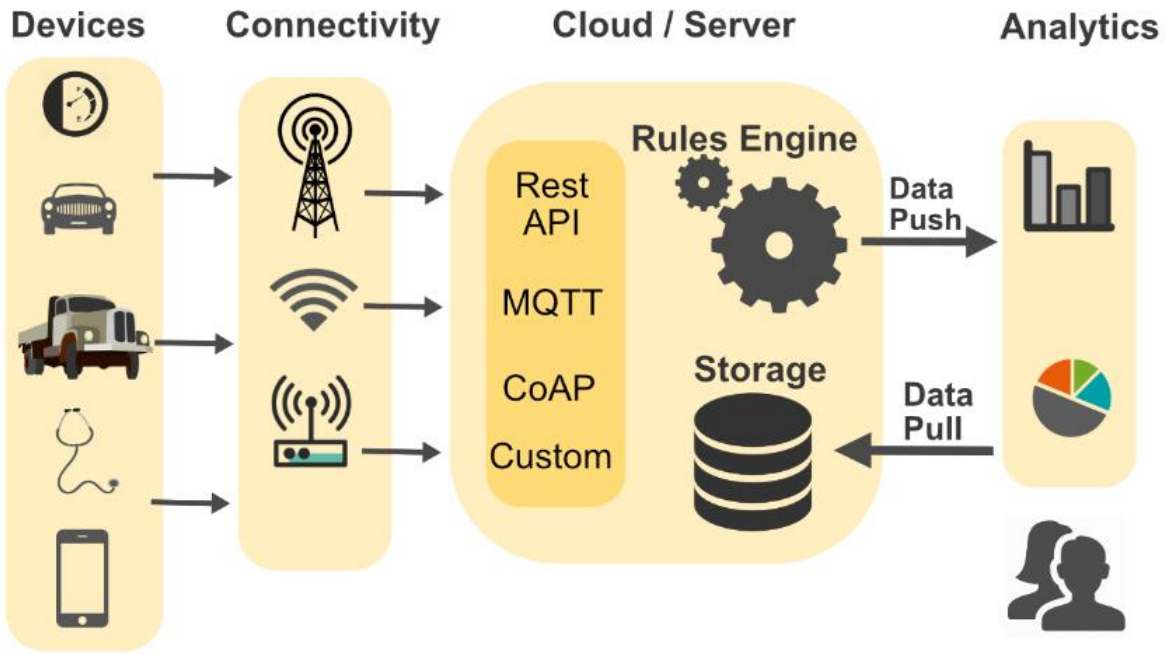
IoT Architecture



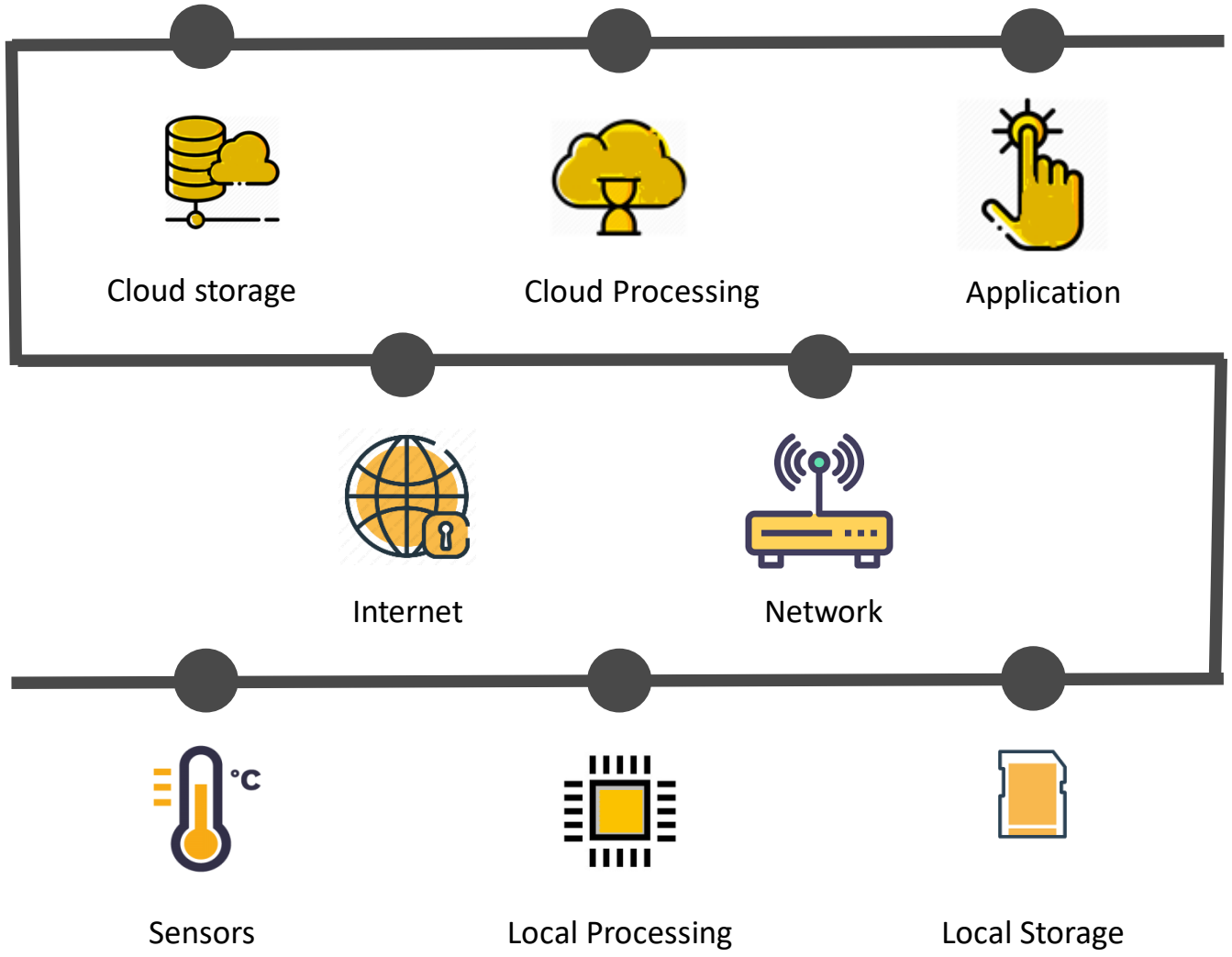
IoT Layers


Application layer
Smart Applications
Middleware layer
Process Information
Networking layer
Data Transmission
Perception layer
Data Gathering

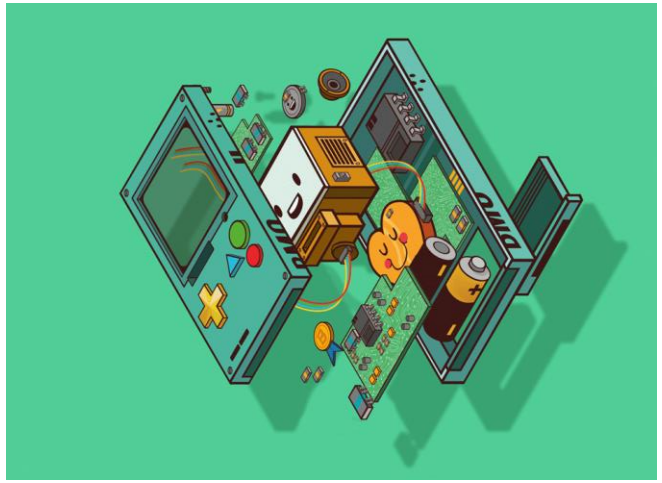
IoT Architecture



Source: Aeris


Cloud storage
Cloud Processing
Application
Internet
Network
°C
Sensors
Local Processing
Local Storage

Hardware and Software

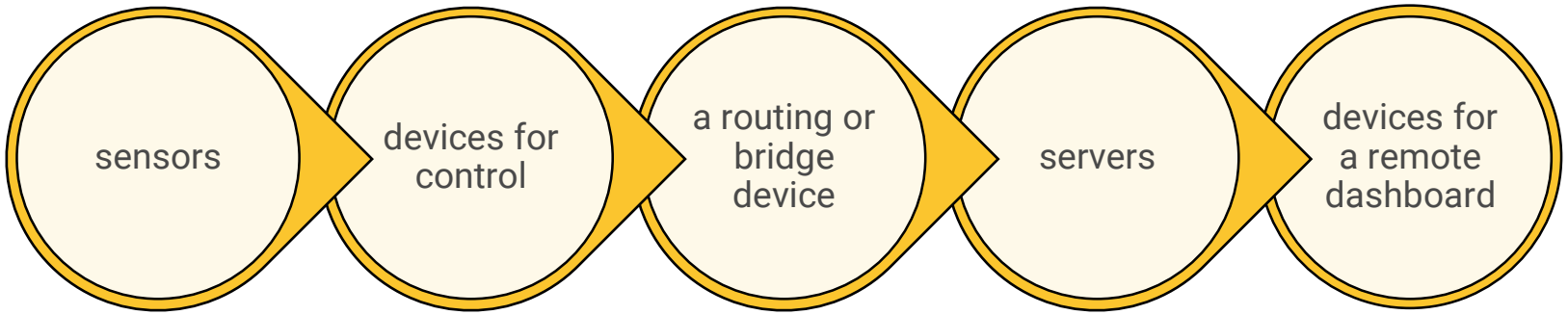


Hardware is a physical part that contains circuit boards, IC's or electronic components

Software is a set of instructions, data or programs used to operate computers and execute specific tasks

Img src: https://dotiview.com, https://careers.kytelearning.com/

Hardware


sensors
devices for control
a routing or bridge device
servers
devices for a remote dashboard

Sensors

What is Sensor?

Detects or measures a physical property and records, indicates, or otherwise responds to it.

Measures and converts it into a signal which can be read by an observer or by an instrument.

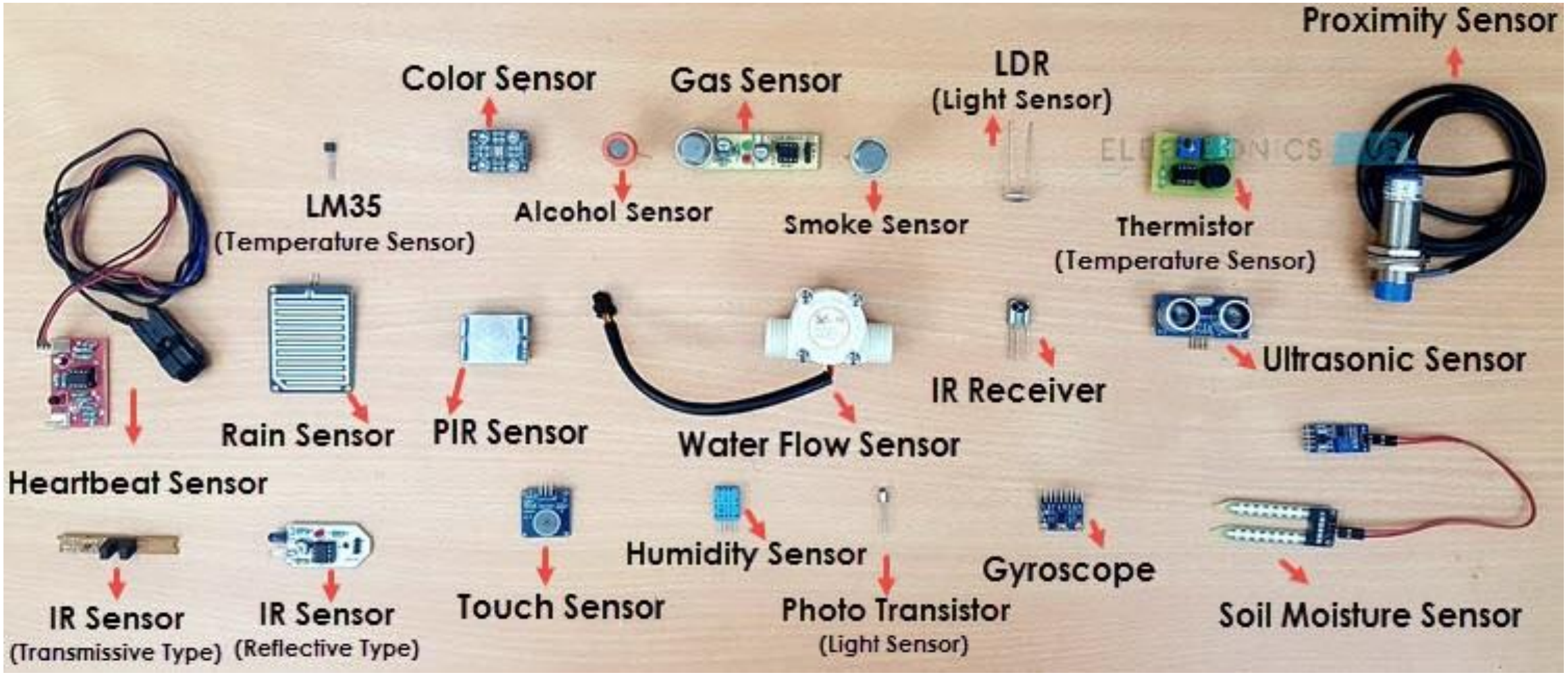
Through which our product senses “anything” in the real-world.

Generally it outputs, electrical or optical signal.

Sensors in IoT

Tremendous types of sensors to detect or measure

Sensors in IoT



But how will I know which controlling device suits well for my solution?

Controlling devices

Task of a Controller device

Converts signal to digital

Processes data

Stores data locally

Local analytics

Communication

Development Boards

- There are many open source boards available in market to start with for
- These development boards are easy to interface as they have multiple interfacing pins such as UART, SPI, I2C, etc.
- Have or cannot have in-built multiple communication modules such as Wi-Fi, BLE, etc.
- Are less power consuming
- Multiple sensors can be integrated
- Many supports Firmware over the air
- Have enough processing power for real time operations and support future upgrades
- Have open source Software platforms

Arduino family

Open source hardware and software

Was started in 2005 with the aim to provide low cost and easy way to create devices

Typically programmed with C and C++ but can be programmed in any language with compiler

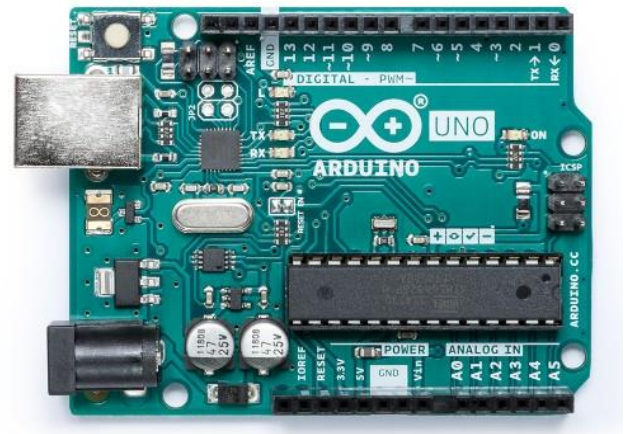
Most Arduino boards consist of an Atmel 8-bit AVR microcontroller

Are preprogramed with boot loaders to simplify uploading of programmes

https://www.arduino.cc/en/main/products

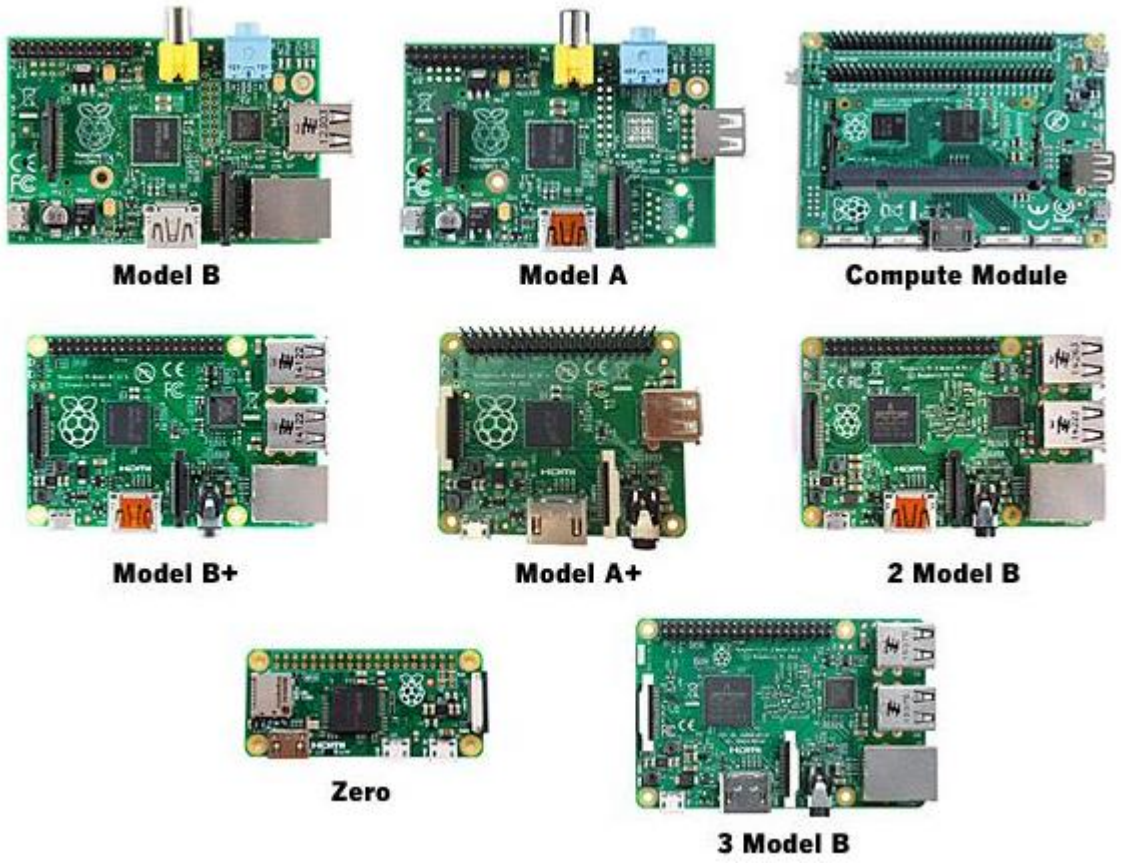
Img src: https://www.sparkfun.com

Arduino Uno



- Most used and documented board
- Best for beginners
- ATMega328P MCU that can be removed and replaced
- Can be powered by 9-12V AC to DC adapter
- Flash: 32 KB of which 0.5 KB used by boot loader
- 14 digital pins(5V), 6 analog pins(0-5V)
- SRAM: 2KB, EEPROM: 1KB
- No OS
- Very cheap

Raspberry Pi family



Low cost mini Computer

Linux based OS

Most widely used for computing

Typically programmed with python

Broadcom SoC with ARM compatible CPU and on chip GPU

Uses SD cards to store OS and program memory

https://www.raspberrypi.org/products/

Img src: https://www.networkworld.com

Raspberry Pi 4

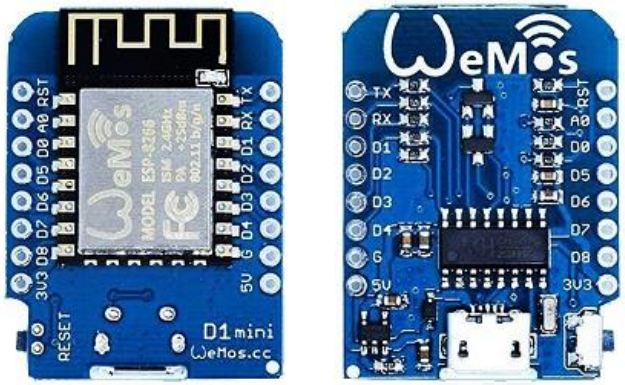
- Powerful processor
- ATMega328P MCU that can be easily removed and replaced
- Can be powered by 5V, 3A USB
- Two USB 2.0, two USB 3.0
- 40 GPIO pins
- Supports 1GB, 2GB and 4GB RAM
- Two micro HDMI ports
- Fast networking

ESP8266 family

- Most preferred Wi-Fi based SoC by Espressif
- Used by third party manufacturers to develop modules
- L106 32-bit RISC microprocessor core based on the Tensilica Xtensa
- 16 GPIO pins, I2C, SPI, I2S, UART, 10bit ADC
- Chip can be directly programmed through Espressif SDK
- https://www.espressif.com/en/products/hardware/development-boards

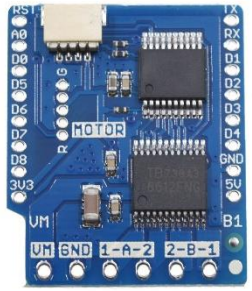
Img src: https://www.instructables.com

Wemos D1 mini



- Most used ESP8266 development board
- Can be powered through USB
- Flash: 4MB
- 11 GPIO pins, 1 analog pin
- Can easily be programmed using Arduino IDE
- Compatible with MicroPython, Arduino, nodemcu

Wemos D1 mini Shields



Motor

Micro SD

PIR

DHT

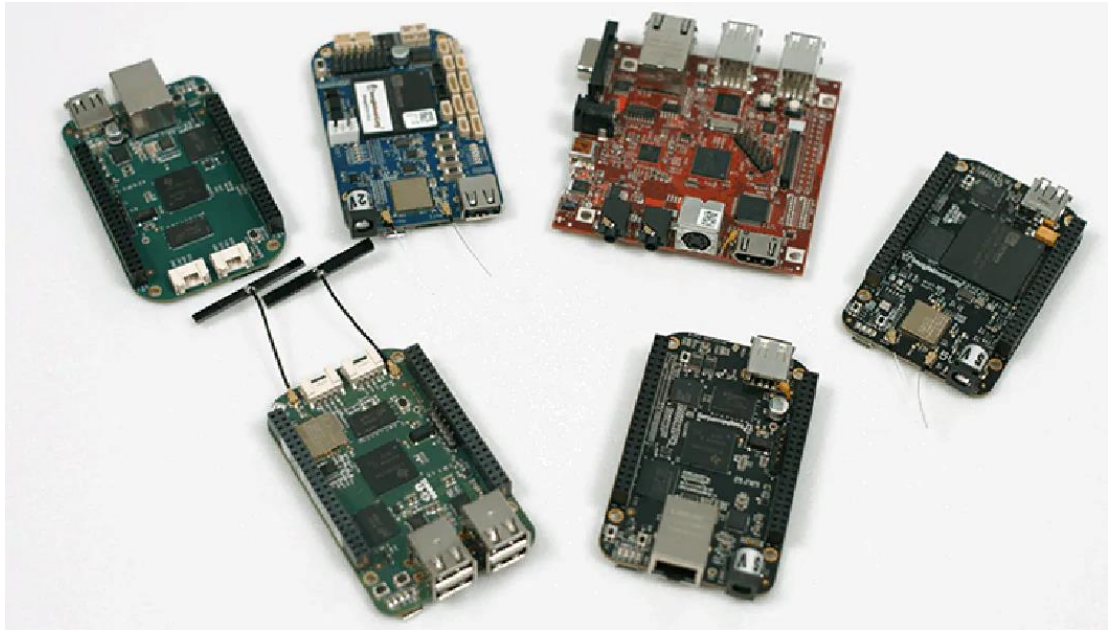
RGB LED

IR Controller

Buzzer

Relay

Beagle Board



Open hardware, open software computers

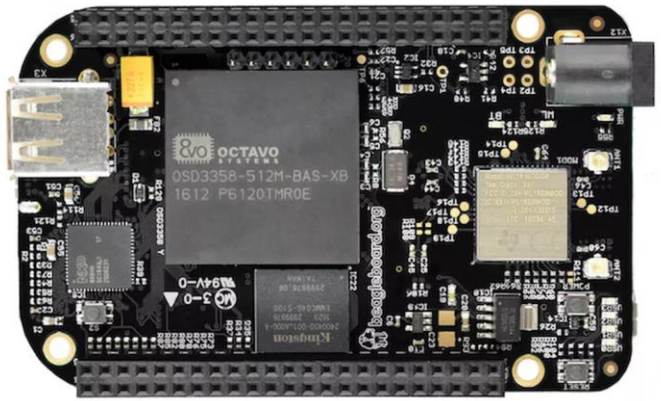
Credit card-sized boards that run Android and Linux

Tiny and power requirements are very low

Arm Cortex A8 series

Img src: https://www.arrow.com

Beaglebone Black Wireless



Octavo Systems OSD3358 , TI AM335x processor

Third-party support of Android, Ubuntu and many more upon open source Linux kernel

Wi-Fi, Bluetooth, and Bluetooth Smart Module

Flash :4GB

RAM: 512 MB

HDMI port

65 GPIO, SPI, I2C, PWM, CAN, UART, SD, quadrature encoders

Ask Questions

What physical signals do I need to measure?

How fast should I measure the real-world signal?

How much processing will you do at the edge?

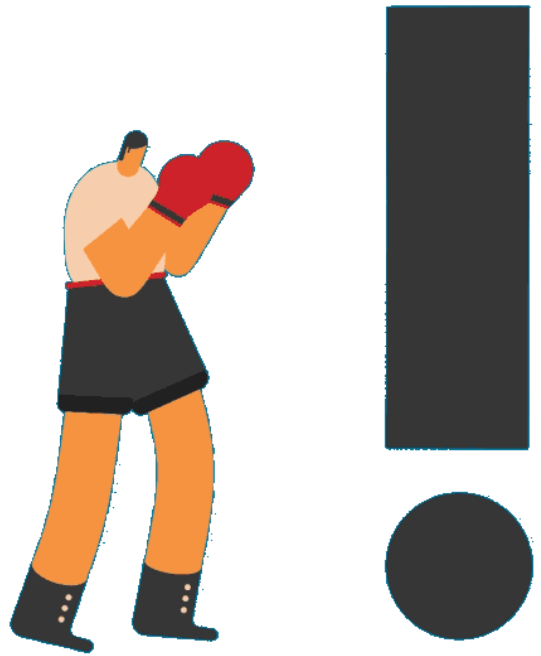
How much data will you need to store at the edge?

How many sensors do I need to read?

What are the software requirements of my board?

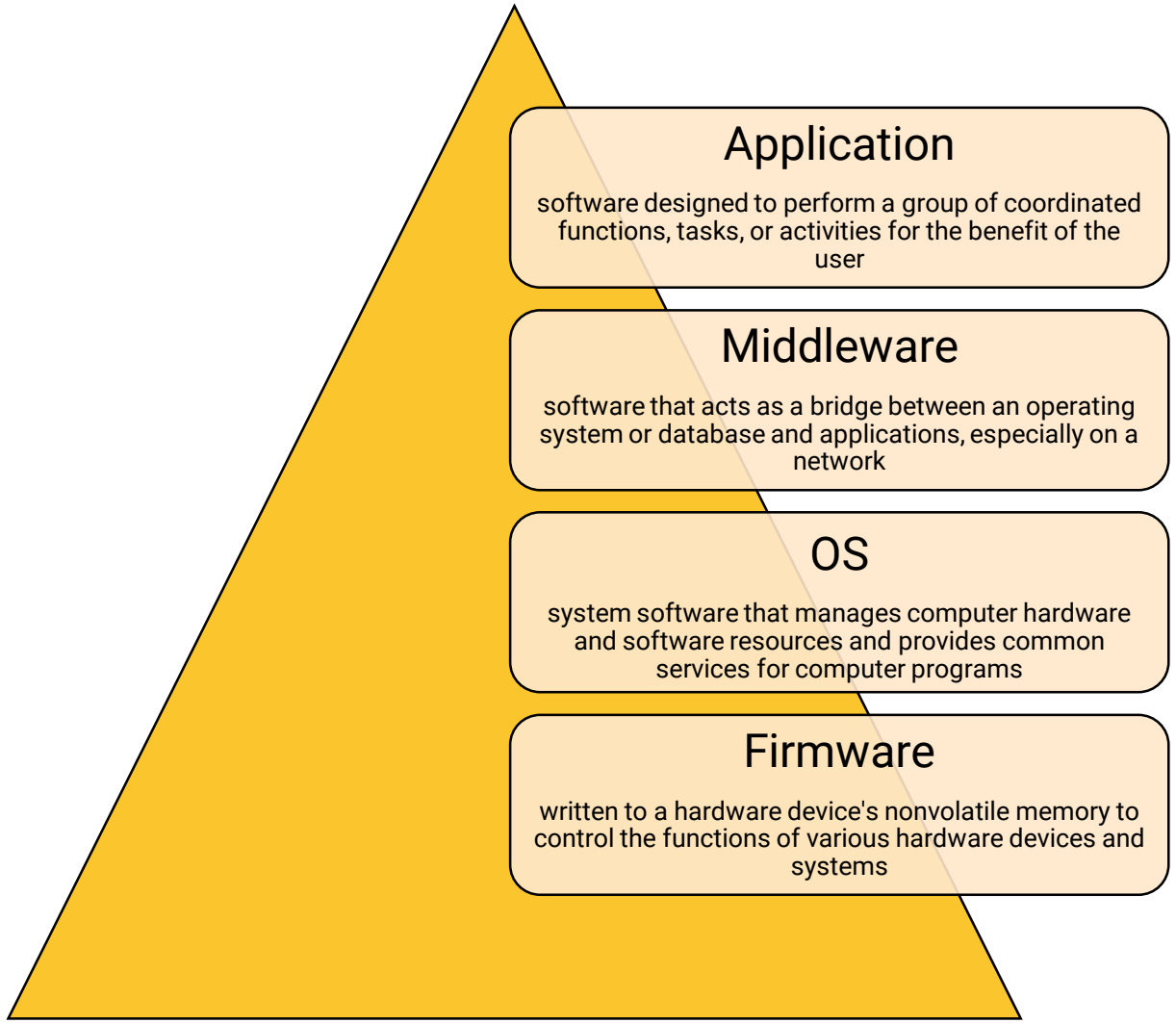
Does my board have all the interfaces i need?

Which communication protocols does it support?



Img src: https://in.pinterest.com

Software


Application
software designed to perform a group of coordinated functions, tasks, or activities for the benefit of the user
Middleware
software that acts as a bridge between an operating system or database and applications, especially on a network
OS
system software that manages computer hardware and software resources and provides common services for computer programs
Firmware
written to a hardware device's nonvolatile memory to control the functions of various hardware devices and systems

Firmware Development platforms

Arduino

- Program microcontrollers using C/C++
- Supports multiple platforms
- Easy to use
- Open source

PlatformIO

- Cross-platform build system without being dependent on external OS
- Support for C and C++ Intelligent Code Completion
- Excellent and modern interface
- Comes pre-equipped with more than 10 frameworks, more than 20 development platforms, and more than 400 embedded boards

Zerynth

- Python and C blended together for efficient development, cross-platform IDE
- Support for HTTPS, SSL/TLS, secure hardware encryption
- Integration with top Cloud services and Firmware Over-The-Air updates
- Integrates the RTOS of your choice with multithreading support

Embedded OS

Embed OS

- Platform and operating system for internet-connected devices based on 32-bit ARM Cortex-M microcontrollers
- provides C/C++ software platform and tools for creating microcontroller firmware

FreeRTOS

- Provides a single and independent solution for many different architectures and development tools
- Has a minimal ROM, RAM and processing overhead
- Offers a smaller and easier real time processing alternative for applications

TinyOS

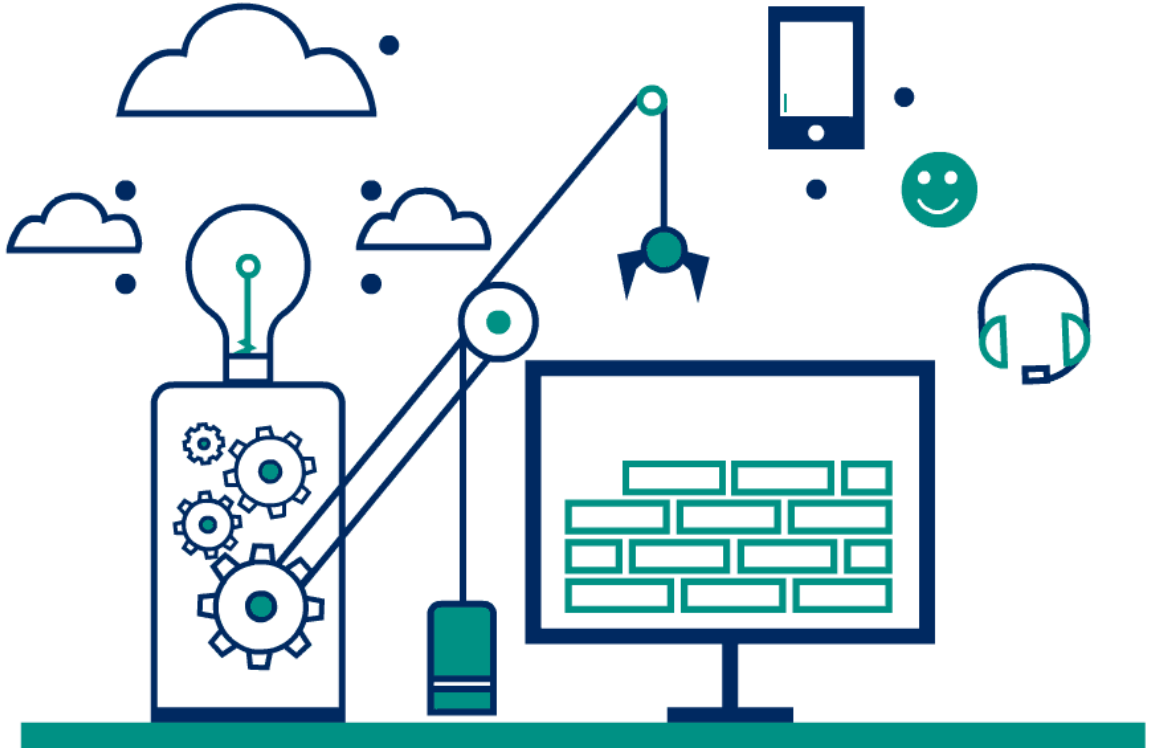
- TinyOS is an embedded, component based OS and platform for low-power wireless devices
- Low memory needed
- TinyOS can be reusable on similar devices
- Small in size

Day 2
Internet of Things

- Step Towards Smart Future

THE BEST WAY TO PREDICT THE FUTURE IS TO CREATE IT.

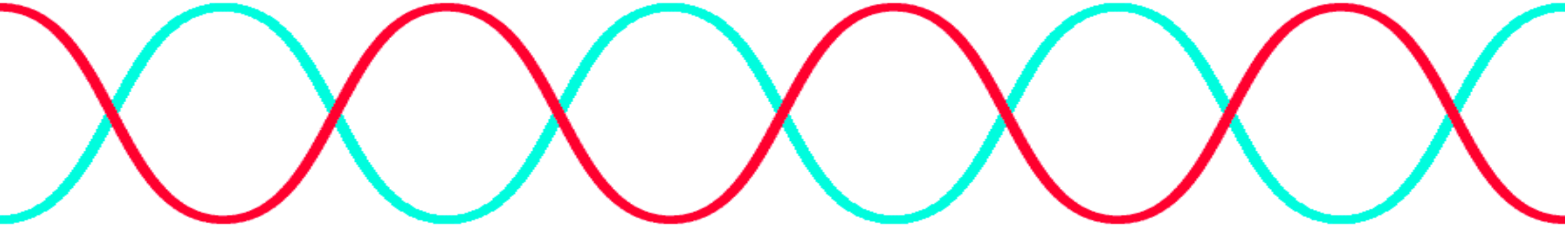
Wireless Communication Protocols



Img src: Giphy.com

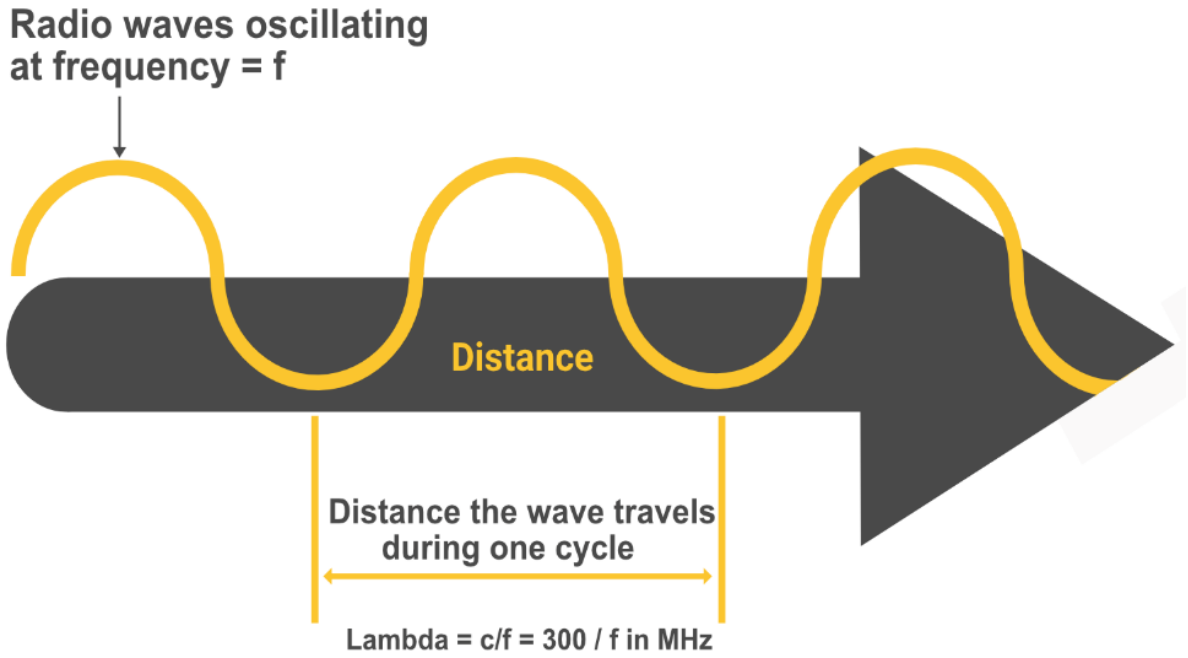
Radio Frequencies

- A radio wave is an electromagnetic frequency used for long distance communication.
- Radio protocols are used by IoT devices to transport data to cloud platforms where a physical or wired connection does not exist.
- There are many different protocols to choose with characteristics varying in areas of power consumption, physical size, travel distance, data size, and transport technology availability.

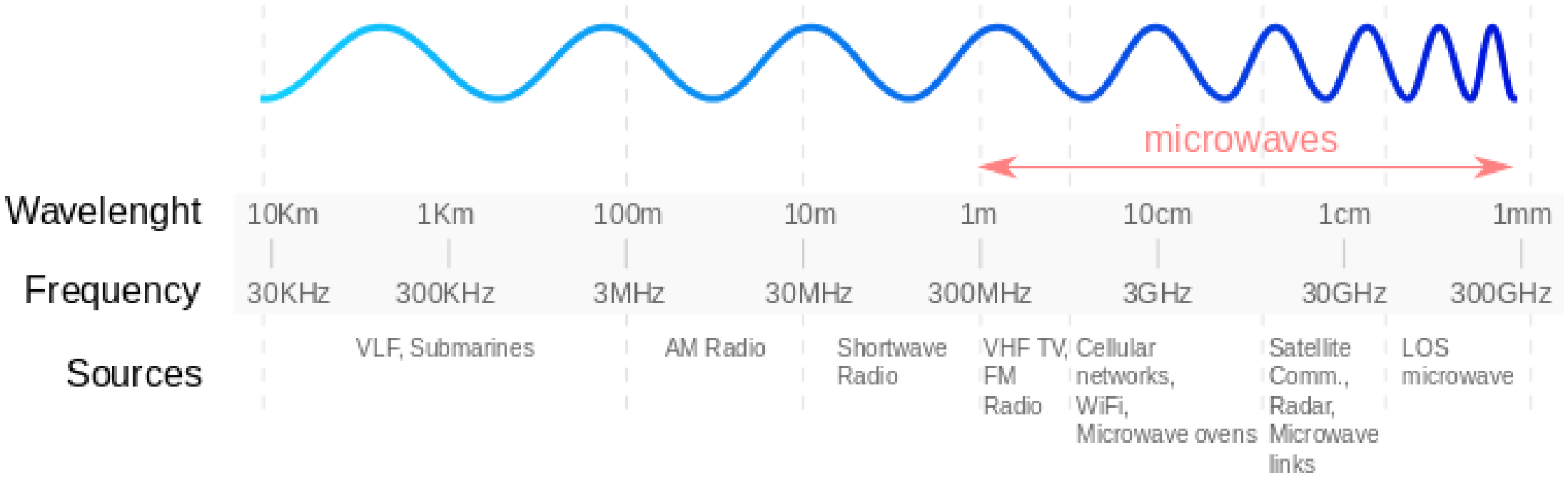


Radio Frequencies

- A radio wave is an electromagnetic wave that travels at the speed of light. The wavelength of an electromagnetic signal is inversely proportional to the frequency.
- Frequency is the number of times per second the signal repeats itself, and is measured in hertz (“Hz”). Phase represents how far the signal is offset from the reference point.



Frequency Bands

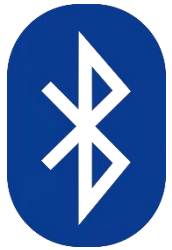


Img src: YateBTS

Frequency Bands (cont.)

- Unlicensed Bands
  - In US popular ISM bands are 433 MHz, 868 MHz, 915 MHz, and 2.4 GHz. Because the 2.4 GHz band is for unlicensed use in most regions, it has become popular for many commercial solutions (e.g. Bluetooth and Wi-Fi).
- Licensed Bands
  - It requires a license from a local regulatory authority to operate in the Licensed Bands. TV and cellular communications are two familiar examples that use licensed frequency bands.
- Forbidden Bands
  - These frequency bands are available for use by government agencies or public service organizations.

Wireless Technologies Used in IoT



Wireless Technologies Used in IoT

Technologies	Frequency	Data rate	Range	Power	Cost
2G/3G	Cellular bonds	10 Mb/s	Several km	High	High
802.15.4	2.4 GHz	250 kb/s	100m	Low	Low
Bluetooth	2.4 GHz	1.2.1.3 Mb/s	100m	Low	Low
LoRa	< 1 GHz	<50 kb/s	2-5 km	Low	Medium
LTE Cat 0/1	Cellular bonds	1-10 Mb/s	Several km	Medium	High
NB-IoT	Cellular bonds	0.1-1 Mb/s	Several km	Medium	High
SIGFOX	<1 GHz	Very low	Several km	Low	Medium
Weightless	<1 GHz	0.1-24 Mb/s	Several km	Low	Low
WI-Fi (11f/h)	2.4.5 <1GHz	0.1-1 Mb/s	Several km	Medium	Low
WirelessHART	2.4 GHz	250 kb/s	100m	Medium	Medium
ZigBee	2.4 GHz	250 kb/s	100m	Low	Medium
Z-Wave	908.42 MHz	40 kb/s	30m	Low	Medium

How to Choose the Correct Radio Frequency

Constraint	Description
Size	Device enclosure size. If constrained, may introduce constraints on antenna size or power supply.
Cost	Each system in the IoT system should have a cost target. A primary input often initially ignored but it will introduce constraints everywhere.
Data	The amount and freuency of data to be captured and sent (e.g. bps). Ideally, a primary input but often constrained by environment, size, or cost.
Serviceability	Each system will have a finite life or a service requirement. Typically constrained by environment and cost, may introduce constraints on power. Also drives standard or proprietary technology preferences.
Power	If main power is unavailable, power becomes a significant design consideration with dependencies on size, environment, cost, data, serviceability, and compute.
Onboard Compute	Requirements for onboard logic and storage vs. remote. Constrained by size, cost, and power.
Simplex/Duplex	The mode of operation is dictated by Data requirements, simplex (one way transmission, send data), or duplex (two way transmission, send and receive).

Examples

- Your device transmits mass amounts of data frequently: You will need high bandwidth solution.
- Your device is size constrained: Your device’s small size will force you to use a solution that can accommodate a smaller antenna and battery.
- Your device must transmit data over a long distance: Your radio solution will need to operate at a lower data rate, use a lower frequency, implement a larger antenna, or increase your power capacity.
- Your device must operate for days, weeks, or months without a re-charge of power: You will need to limit the range, reduce the data amount and frequency, and or invest in a more expensive power technology such as high density batteries or energy harvesting.

Wireless technology

1. Long Range IoT Radio Solution
2. Medium Range IoT Radio Solution
3. Short Range IoT Radio Solution

Img src: sap.com

Long Range IoT Radio Solution

Img src: rdtech-energy.com

Cellular Technologies

- Many IoT solution leverages cellular networks for long range connectivity.
- Cellular networks are established.
- Cellular networks: From 1G to 4G
- 1G: First generation wireless cellular: Early 1980s
  - Analog transmission, primarily speech: AMPS (Advanced Mobile Phone Systems) and others
- 2G: Second generation wireless cellular: Late 1980s
  - Digital transmission
  - Primarily speech and low bit-rate data (9.6 Kbps)
- 2.5G: 2G evolved to medium data rate (< 100Kbps) data
- 3G: Third generation wireless cellular: 2001 (WCDMA)
  - 144 Kbps – 384 Kbps for high-mobility, high coverage
  - 2Mbps for low-mobility and low coverage
- 4G: Fourth Generation wireless cellular: 2009 (LTE)
  - Peak download 100 Mbit/s
  - Peak upload 50 Mbit/s

- IoT companies started retiring the 2G devices since AT&T shut down the 2G service in 2016.

Disadvantages of Cellular Technologies

- Use of cellular networks can be expensive.
- These networks are designed for voice and high data throughput/low latency communications, which are not typical requirements of IoT applications.
- The protocols and interfaces are difficult to customize for unique applications.
- The cellular device certification processes are time consuming and expensive.
- Cellular solutions are not designed for very low power operation.
- With the push to increase data rates and high data spectrum efficiency, older 2G and 3G infrastructure will likely begin to phase out.

LPWA (Low Power Wide Area) Networks

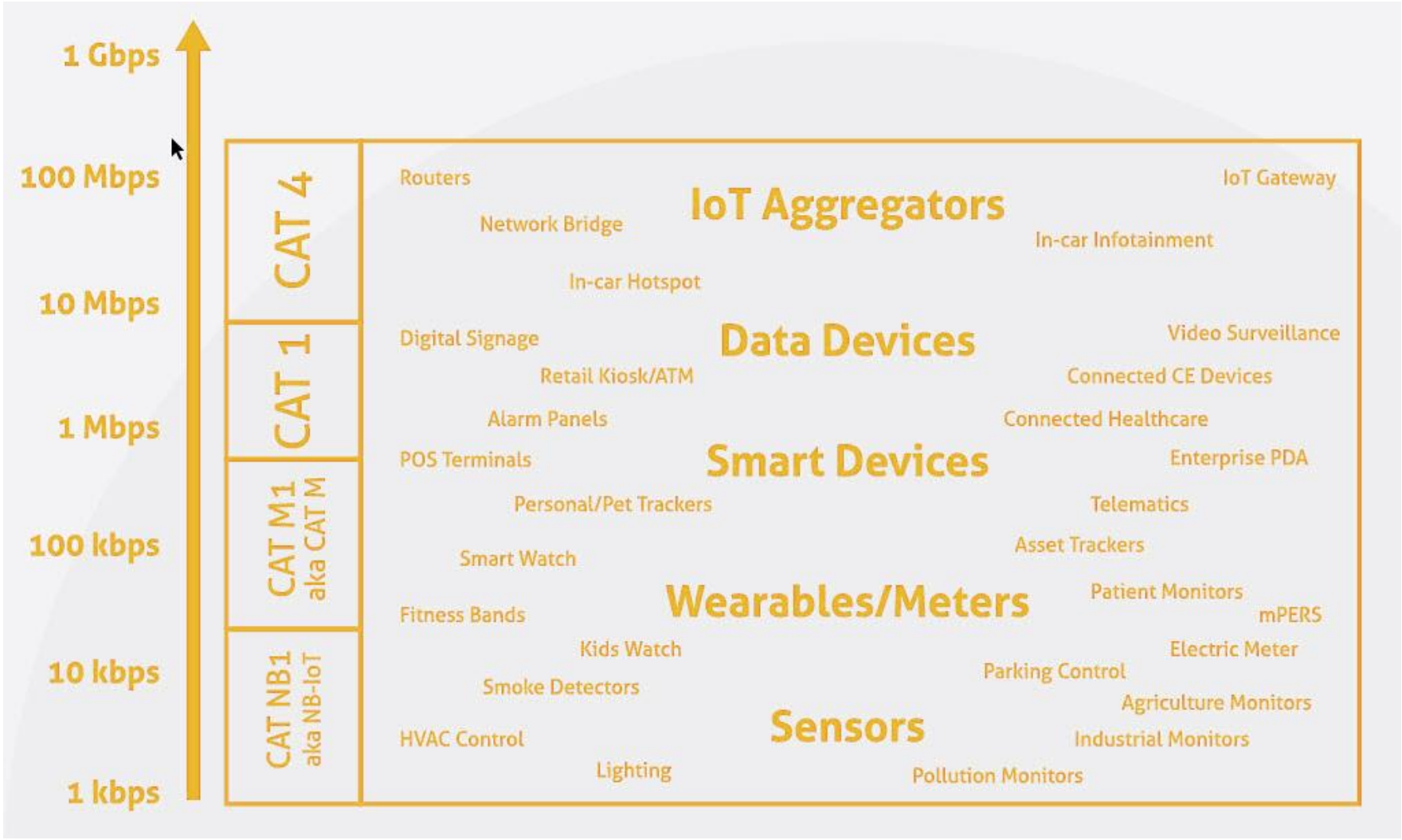
LPWA Advantages

- Long Range – The end-nodes can be up to 10-15 KM from the gateway, depending on the Technology deployed.
- Low Data Rate – Less than 5,000 bits per second. Often only 20-256 bytes per message are sent several times a day.
- Low Power Consumption – LPWA does not consume much power which makes it possible to have very long battery life, often between 5-10 years.

LPWA (Low Power Wide Area) Cellular Technologies

	LTE Rel - 8 Cat - 1	LTE Rel - 12 Cat - 0	LTE Rel - 13 Cat - M1	NB-IoT
DL peak size	10 Mbps	1 Mbps	1 Mbps	~0.2 Mbps
UL peak rate	5 Mbps	1 Mbps	1 Mbps	~0.2 Mbps
Duplex Mode	Full	Half or Full	Half or Full	Half
UE Bandwidth	20 MHz	20 MHz	1.4 MHz	0.18 MHz
Relative Modem Complexity	100%	50%	20-25%	10%

LTE Technologies

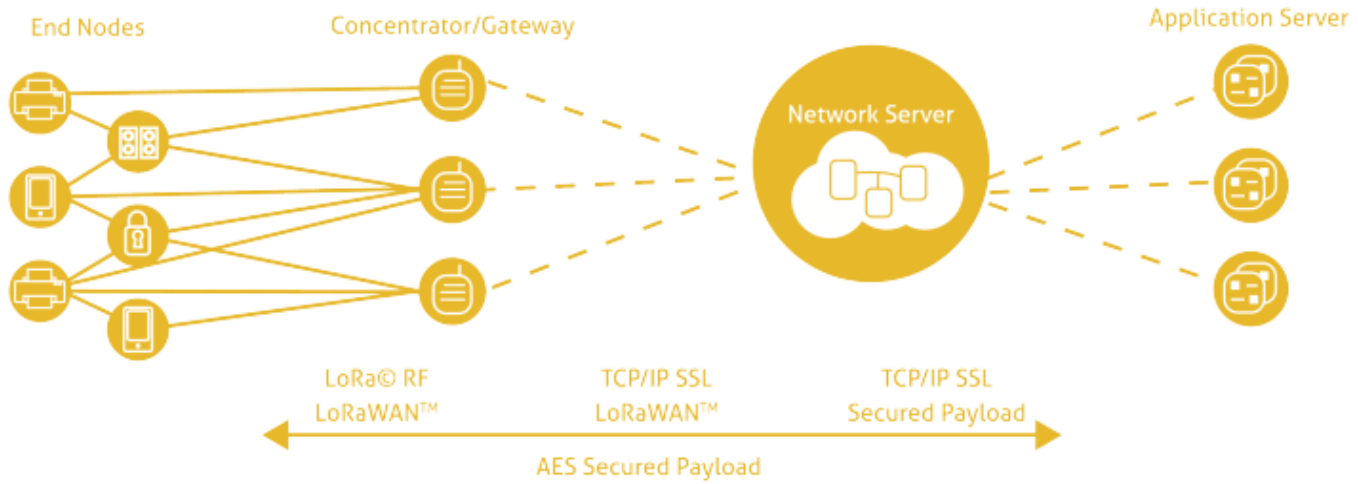


LoRa

- LoRa is the short form of Long Range.
- It offers a compelling mix of long range, low power consumption, deep indoor coverage, and secure data transmission.
- LoRa operates in the unlicensed <1GHz frequency range.
- LoRa data rates range from 0.3 kbps to 50 kbps and can support a range of up to 15km.
- LoRa is a Low Power radio technology and supports long battery life.

LoRaWAN

- The network server handles all the intelligence and complexity associated with managing the network.
- The LoRaWAN network server uses an adaptive data rate (ADR) approach this helps in preserving battery life for the end devices.
- LoRaWAN is also an asynchronous protocol which is beneficial for improved battery life.
- To enable secure communication, LoRaWAN uses several layers of encryption at the device, network, and application levels.



LoRa - Usage

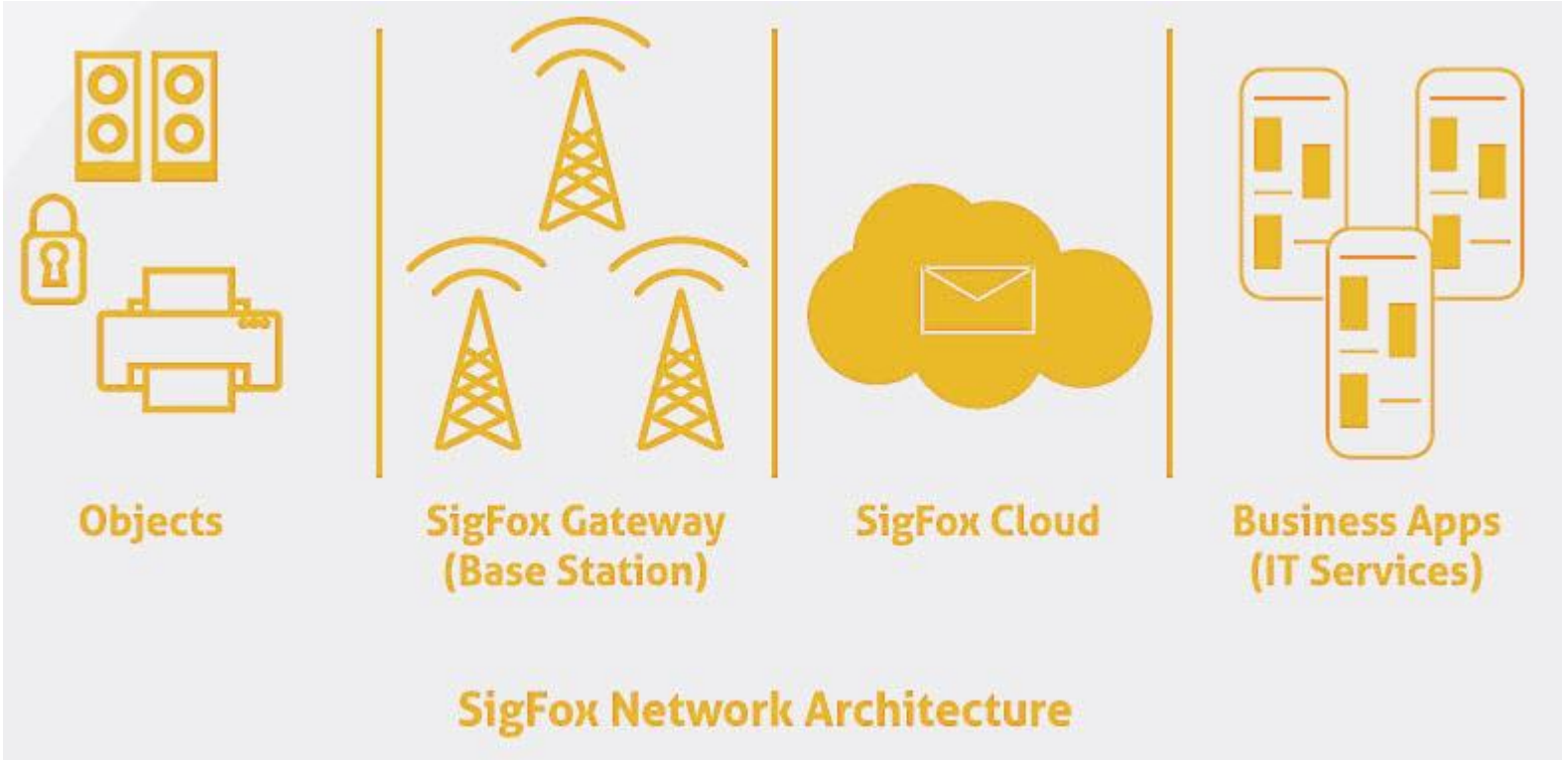
- Cost of transmitter devices (End Nodes) is less, but the Gateways are very expensive.
- LoRa is not suitable for the price sensitive use cases like Home Automation.
- It is not ideal for systems that send large amounts of data, require guaranteed quality of service (QoS), or require low latency or tight synchronization.
- It is an attractive solution for use cases like rural meter reading.
- LoRa can be used for Smart City initiatives and agriculture.
- It can be used in Waste Management industry by helping to collect the bins when they are full.

Sigfox

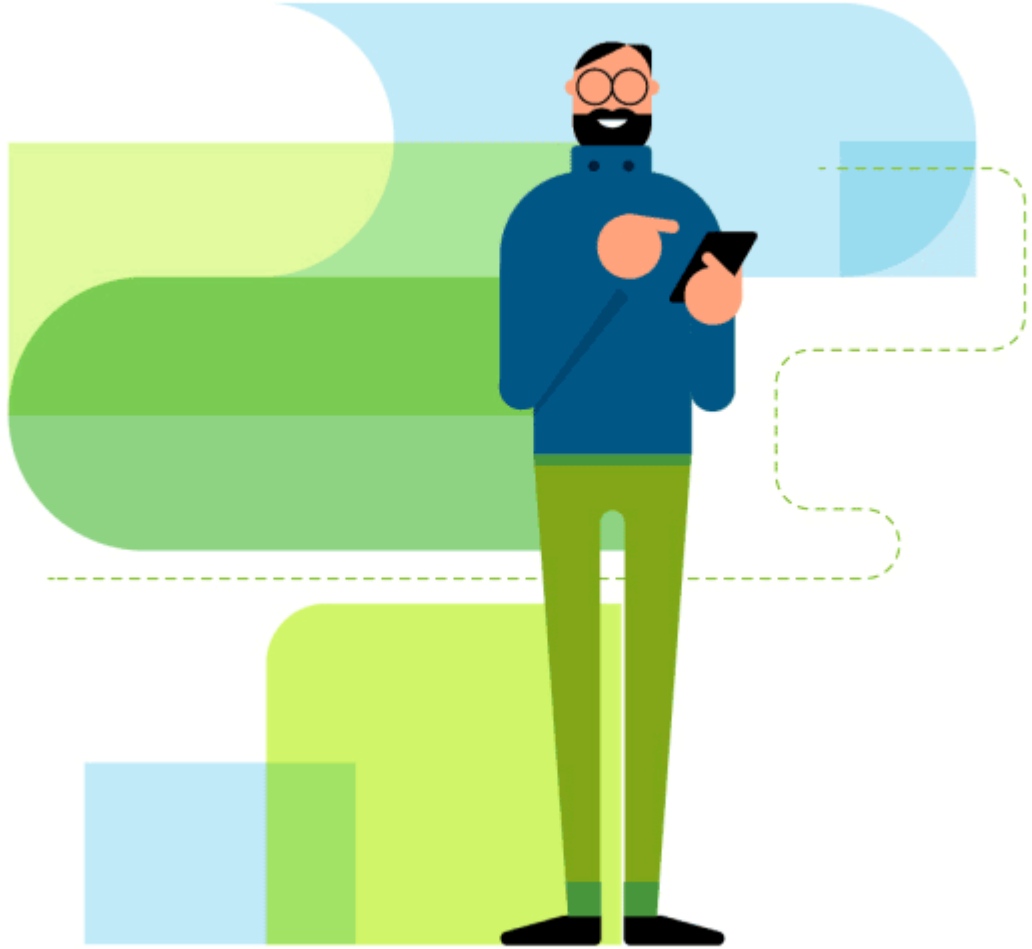
- Sigfox is a French company founded in 2009 and the network is mostly deployed in France.
- It operates in unlicensed ISM band – 868 MHz in Europe and 915 MHz in US.
- The range is about 30 to 50 KM in rural areas and 3 to 10 KM in urban areas.
- Sigfox uses a patented technology called ultra Narrow Band (UNB) with binary phase-shift keying (BPSK).
- Sigfox is suitable for low throughput(<100bps) and low frequency (<140 messages/ day) applications.
- Sigfox power consumption is very less, e.g. – energy meters using Sigfox will consume 50 microwatts while with GSM Cellular system it consumes 5000 microwatts.
- Standby time for a 2.5Ah battery is almost 20 years with Sigfox.

Sigfox

- Sigfox controls the back end, communications infrastructure and cloud management platform. Therefore, any customer who wants to use Sigfox must subscribe to both its communications infrastructure and its cloud platform. Radios and modules forend points are widely available from manufacturers like Texas Instruments, Atmel, and Telit.



Medium Range Radio Solution



Medium Range IoT Radio Solution

- Medium range radio solutions have signal range no greater than 100 meters.
- Some of these technologies may use a star or mesh node architecture to acquire greater range.
- These technologies are sometimes referred to as “Local RF.”
- The most common medium range technologies include ZigBee, Z-Wave, Wi-Fi, and Thread.

IEEE 802 Wireless Standards

- It is a family of networking standards covering physical layer specifications of technologies from Ethernet to Wireless.
- IEEE 802 is subdivided into 22 parts.

Standard	Used In
802.3	Ethernet
802.11	Wi-Fi
802.15.1	Bluetooth
802.15.4	ZigBee

Wi-Fi Features

- Wireless Fidelity or Wi-Fi is the go-to standard for moving large amounts of data across a wireless network.
- It is based on the IEEE 802.11 family of standards.
- Ethernet connection replacement.
- Wi-Fi is less secure than wired connection, such as Ethernet
- Operates in the unlicensed 2.4 GHz and 5 GHz bands.
- Range is up to 100m (but typically in 30-50m range).
- Data Rates: 150-200 Mbps is typical on 802.11n, (802.11-ac standard offers 500 Mbps to 1Gbps)
- 5 Frequency ranges : 2.4 GHz, 3.6 GHz. 4.9 GHz, 5 GHz, 5.9 GHz

Wi-Fi – 802.11 family specifications

- **802.11** - This pertains to wireless LANs and provides 1 or 2 Mbps transmission in the 2.4 GHz band using either frequency-hopping spread spectrum (FHSS) or direct- sequence spread spectrum (DSSS).
- **802.11a** - An extension to 802.11 that supports up to 54 Mbps in the 5 GHz band. This employs the orthogonal frequency division multiplexing (OFDM) encoding scheme.
- **802.11b** – An extension to 802.11 that supports connections up to 11 Mbps in the 2.4 GHz band. The 802.11b specification uses only DSSS.
- **802.11g** - This enhancement (combining the best of 802.11b and 802.11a) provides up to 54 Mbps in the 2.4 GHz band. Note that 802.11g is backward-compatible with 802.11b.

Wi-Fi – 802.11 family specifications (cont.)

- **802.11n** – This enhancement incorporates MIMO (multiple inputs multiple outputs) utilizing multiple wireless signals and antennas to improve on 802.11g and supports up to 300 Mbps. Note that 802.11n is backward-compatible with 802.11b/g.

- **802.11ac** – This enhancement utilizes dual band operation, supporting simultaneous connections on both the 2.4 GHz and 5 GHz bands to achieve data rates >1 Gbps. 802.11ac also incorporates MIMO as well as beam-forming (focuses a signal in a particular direction). Note that 802.11ac offers backward-compatibility to 802.11b/g/n.

ZigBee Features

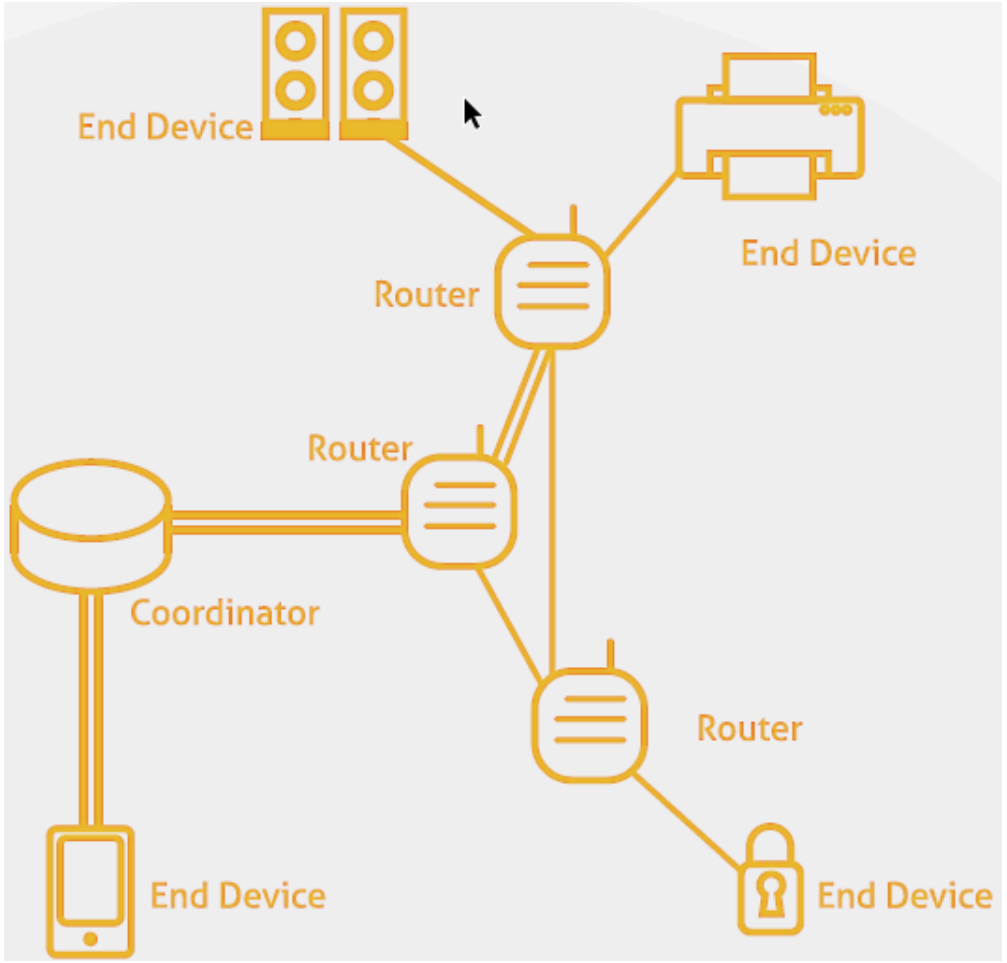
- ZigBee is built on top of IEEE 802.15.4 standards.
- Operates at 2.4GHz (for global use) at 250kbps, but the standard defines radios at 868MHz European Band at 20kbps and 915MHz North American Band at 40kbps, as well.
- Supports data rates as high as 250kbps, though the data rates are typically much lower.
- Uses Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA), allowing multiple devices to share the same frequency channel.
- Uses spread spectrum communications to improve performance in multipath, noisy, and low signal strength radio environments.

ZigBee Features (cont.)

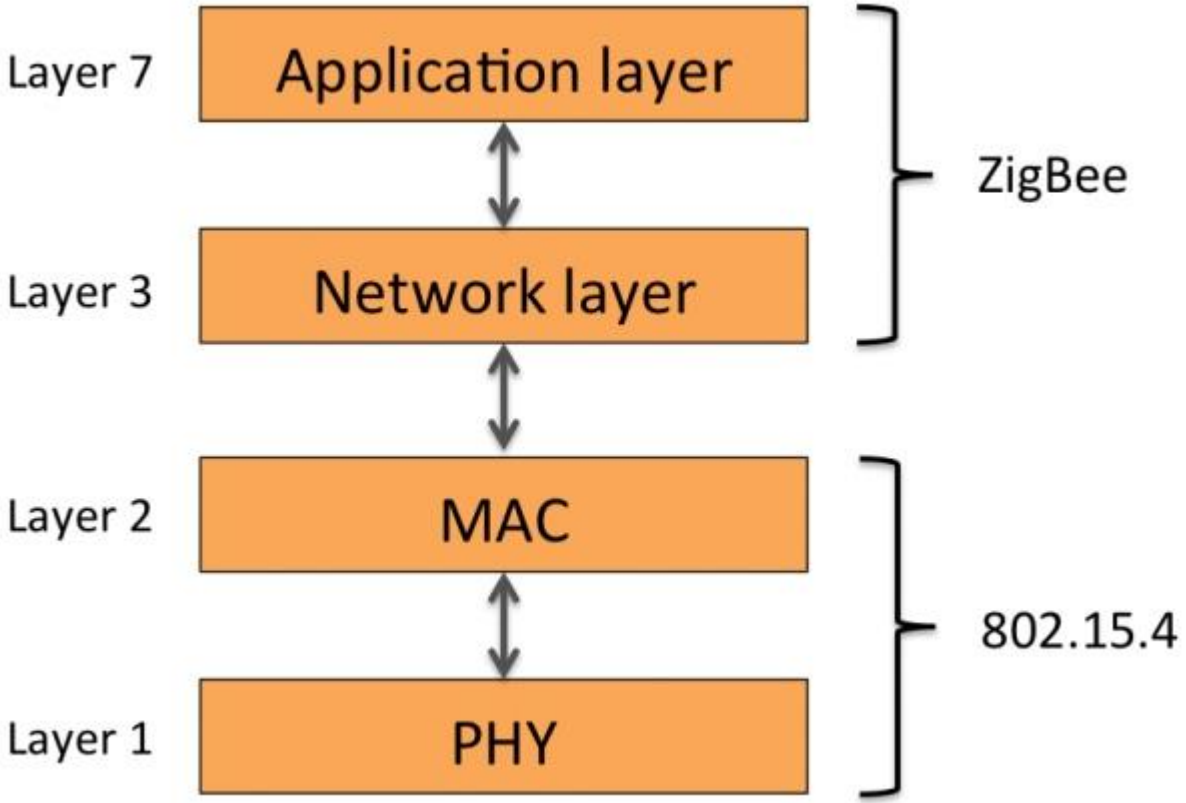
- Supports up to 65,000 nodes.
- Uses association and disassociation to allow devices to join or leave a network. This process allows for self-forming and self-healing capabilities.
- Provides security using 128-bit AES encryption for secure data connections.
- Allows a range between 10 to 100 meters for ZigBee applications.
- Support multiple topologies – Mesh, Star, One to One

ZigBee Network

- ZigBee system architecture consists of 3 types of devices:
  - 1. ZigBee Coordinator (ZC)
  - 2. ZigBee Router (ZR)
  - 3. ZigBee End Devices (ZED)
- IEEE 802.15.4



IEEE 802.15.4 & ZIGBEE



ZigBee Pros & Cons

Advantages	Disadvantages
Low Power	Low Data Rate (250kbps)
Supports multiple topologies – Mesh, Star, One to One	Very Expensive
The communication range is long (10m to 2Km)	The frequencies other than 2.4GHz requires licensing in some countries
The Nodes can be scalable with little configuration	

ZigBee - Usage

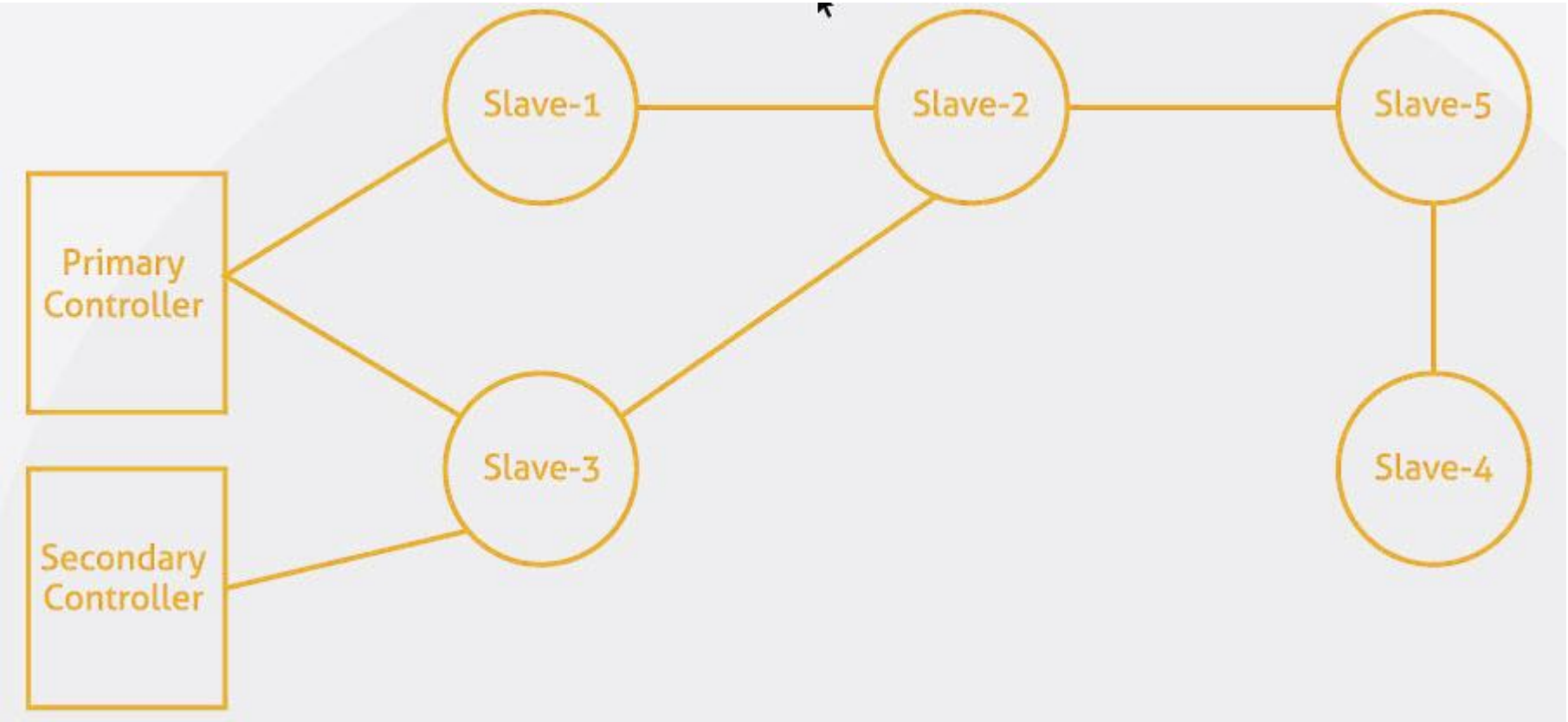
- Industrial Automation
- Home Automation
- Smart Metering
- Wireless Sensor Network

Z-Wave – Features

- Operates in the <1GHz band, with unique channels in Europe and North America.
- Sub Giga hertz frequency band – 900 MHz, 100 Kbps
- Uses frequency shift keyed physical modulation (FSK).
- Supports variable data rates from 40kbps up to 100kbps.
- Supports up to 232 nodes in a Z-Wave network.
- Supports a range of up to 30 meters.
- Uses AES-128 symmetric encryption for increased security.
- Supports broadcast and multicast modes.

Z-Wave – System Architecture

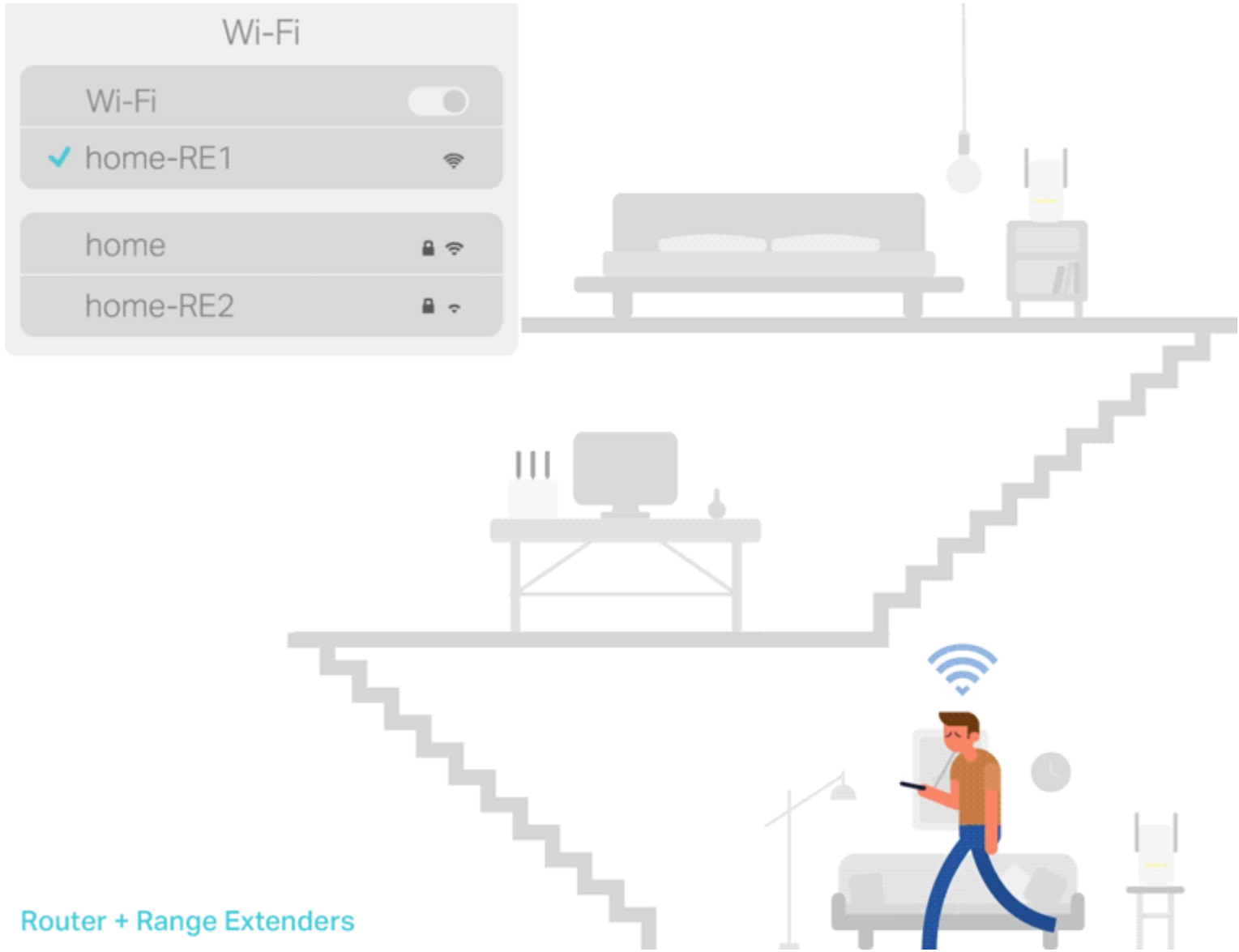
- Z-Wave supports full mesh network.
- The nodes are either Controller or slave.



Z-Wave Pros & Cons

Advantages	Disadvantages
Ultra Low Power Consumption	Low Data Rate (100kbps)
Supports Mesh topology and This rely system greatly extends its range	Limited Number of Nodes per network
Ideal for Home Automation	Not suitable for Industrial Application

Short Range IoT Radio Solution



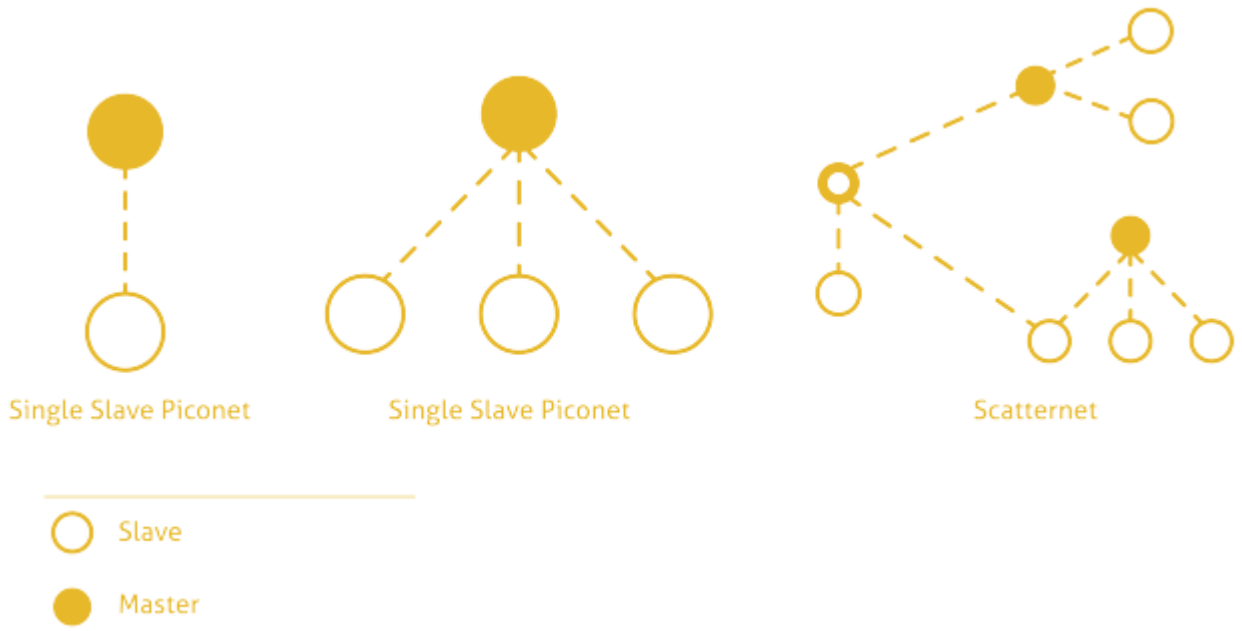
decoM9Plus from ebay

Bluetooth - Features

- Bluetooth standard is generally intended as a “cable replacement” technology. It is used for transferring medium amounts of data over a relatively short distance.
- Open standard for development of Personal Area Network (PAN).
- Bluetooth operates in the unlicensed 2.4 GHz ISM band.
- This technology has features such as low cost, low power, and a short range
- A Bluetooth enabled device can exchange information to other BT enabled devices over a radio frequency.

Bluetooth - Network

- A Piconet can have one Master and up to 7 Slaves.
- Combination of multiple piconets is known as Scatternet. A device can participate in multiple piconets.



Bluetooth Power Classes

- Power control is used to keep the radiation within the limit so that system works efficiently without interfering with the neighbor Bluetooth devices.

Constraint	Power Limit	Range
Class 1	100 mW(20dBm) to achieve maximum range. Minimum 1mW	100 meters
Class 2	Max. output power 2.4 mW(4dBm) Min. output power 0.25 mW(-6dBm)	10 meters
Class 3	Nominal is 1mW	1 meter

Bluetooth - Usage

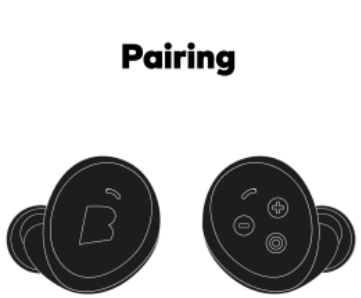
- “cable replacement” technology.
- Used for transferring medium amounts of data over a relatively short distance (30m).
- Bluetooth is widely accepted in audio applications, such as cell phone headsets and wireless speakers.

Bluetooth – Pros & Cons

Advantages	Disadvantages
Ad Hoc Connection	Low Data Rate
2.4 GHz Frequency Ensures World Wide Operations	Interference from other Devices working on same band
Implemented by a large number of Companies	Short Range
Suitable for creating a Pico Net	High Power Consumption

Bluetooth - Usage

iPega 9023



howtofixheadphones

sennheiser

Linea pro

BT.com

Bluetooth Low Energy (BLE)

- Bluetooth Low Energy was originally introduced under the name Wibree by Nokia in 2006.
- It was merged into the main Bluetooth standards in 2010, when Bluetooth Core Specification version 4.0 was adopted.
- Bluetooth low energy technology is an integral part of the Bluetooth Core Specification from Bluetooth v4.0 onwards.
- Enable a new and extended range of applications to benefit from Bluetooth wireless technologies including watches, proximity tags, sport and fitness sensors.
- Is a wireless personal area network technology designed and marketed by Bluetooth Special Interest Group.
- Low cost

BLE - Features

- Range – 50 meters
- Operates in the unlicensed 2.4 GHz ISM band.
- Over the air data rate is 1 Mbit/s.
- It uses Adaptive Frequency Hopping Spread Spectrum modulation technique.
- BLE devices are detected through a process based on broadcast advertising packets.

BLE – Pros & Cons

Advantages	Disadvantages
High Data Rate	Initial Setup time is more
Low Power Consumption	Interference from other Devices working on same band
Medium Range of 200 feet	The Bluetooth Tags are very Expensive and requires power
Implemented by a large number of companies	

BLE – Usage (Use Cases)

- Blood Pressure Monitor
- Fitbit like devices
- Industrial monitoring sensor
- Geography/ proximity based targeted promotion (Beacon)
- Battery status
- Browse over Bluetooth
- Personal User Interface

Fitbit Charge 3 Fitness Activity Tracker

Example of BLE blood pressure monitor.
Source: Nordic Semi Conductor

RFID - Features

- Radio Frequency Identification (RFID) is a data collection technology similar to barcodes.
- It does not need any scanning, instead uses radio frequency communication to collect data from RFID tags.
- An electronic tag (Transponder) is embedded with an integrated circuit (IC) that can store unique data about the object being tagged.
- A reader (Interrogator) transmits radio waves at a specific radio frequency to communicate with and retrieve data from tags within its proximity

Passive RFID

- Passive RFID systems use tags with no internal power source.
- The tags only have two main components – Antenna and the microchip or IC.
- The IC of passive RFID tag gets power from the Electro-Magnetic energy transmitted by the reader.
- Passive RFID tags comes in two forms – Hard Tags and Inlays.
- Hard tags are durable, made of plastic, ceramic, rubber.
- Inlays are cheaper RFID tags and generally they can be peeled off a roll and stuck in an item for tracking using a Reader.

Passive RFID Frequency

- There are three main frequencies in which passive RFID tags work.
- 125-134 KHz (Low Frequency) – Read range of about 1-10 centimeters.
- 13.56 MHz (High Frequency & Near-Field Communication) – Read range of 1 centimeter to 1 meter.
- 865-965 MHz (Ultra High Frequency) – Read range of 5-6 meters.

Advantages of Passive RFID

- Smaller tags, can be attached to almost any asset.
- Much cheaper tags (in sub-dollar range).
- Thinner and more flexible tags to stick on different types of surfaces.
- Higher range of tag options.
- Tags can last long time without a battery (depending on the wear and tear)

Close up of RFID inlays.
Source: RFID Insider

Active RFID

- Active RFID Tags have their own power source - an internal battery that enables them to have extremely long read ranges as well as large memory banks.
- It have three essential parts – Reader or Interrogator, Antenna and a micro chip or IC.
- Two different types of Active RFID tags are available – Transponder and Beacon.
- Transponder sends a signal only when it receive a signal from the Reader first. They conserve the battery life this way. They are used in secure access control and toll booth payment systems.
- Beacon tags continuously send out the signal every 3-5 seconds. They are mostly used in oil and gas industry.

Advantages of Active RFID

- Extremely long read range.
- Tags available with other sensors (temperature, humidity, GPS).
- Extremely rugged tag options available.

Example of a type of rugged tag option.
Source: RFID Insider

Advantages of Active RFID

Advantages	Disadvantages
The RFID tags are easy to install	In case tags are installed in Fluids or Metals, the reader find it to difficult to read
Can store up to 2KB data	RFID is referred as Invasive Technology
RFID can not be replicated easily hence it is more secure	Different countries have different frequency ranges

RFID – Usage (Use Cases)

- RFID technology is widely used for asset tracking, inventory management type use cases.
- It is used for physical inventory of fixed assets and can also track assets in real- time.
  - RFID Can read multiple tags simultaneously
  - RFID does not require Line-Of-Sight

- People Tracking
- Retail & Inventory Tracking
- Parking Solution
- Manufacturing

Gfycat.com

IoT Data Comm. Protocols

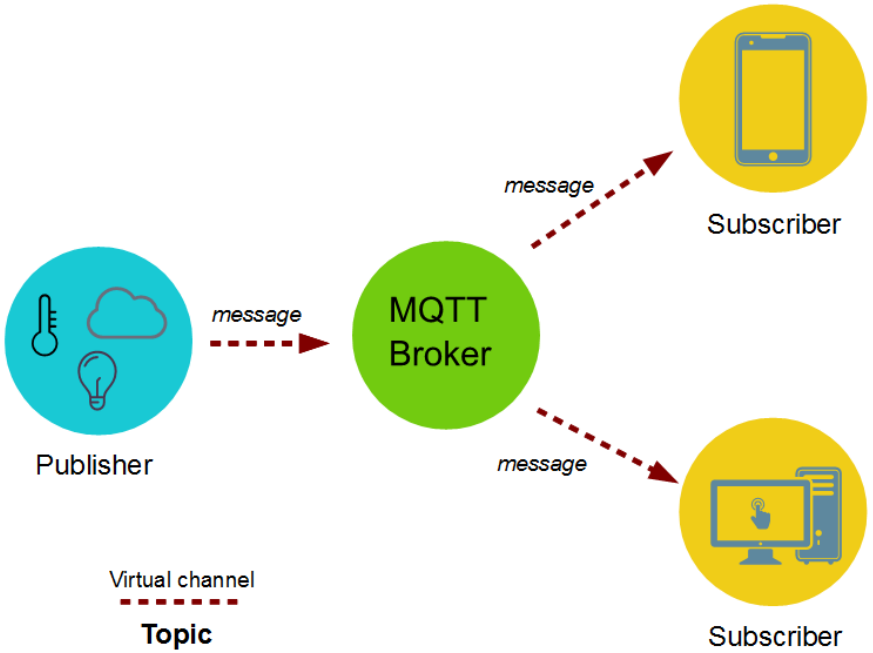
Dribbble.com

MQTT

MQTT(Message Queue Telemetry Transport) is a Client Server publish/subscribe messaging transport protocol.

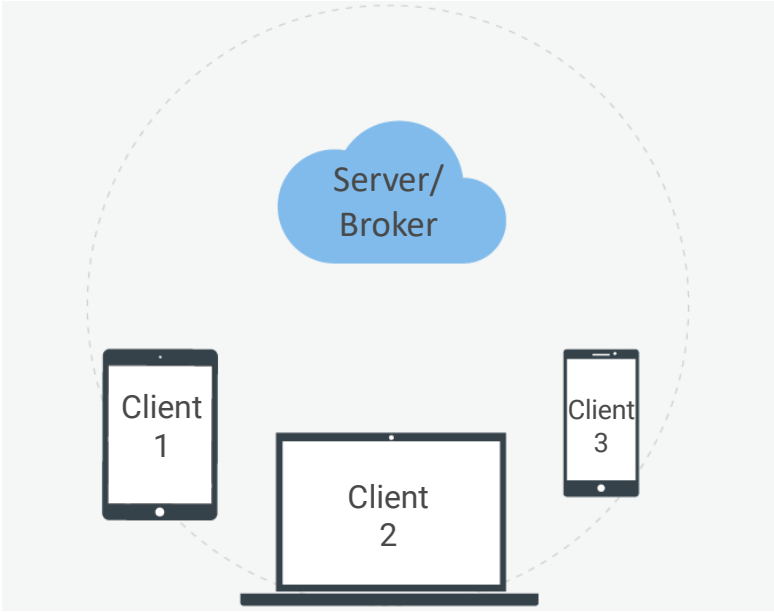
This protocol is widely used in the field of IoT for communication between Machine to Machine because of its following features ,

- Light weight,
- Open, and
- Designed so as to be easy to implement.



MQTT - Features

- Works on top of TCP/IP
- Client libraries for Android, Arduino, C, C++, C#, Java, JavaScript, .NET
- Security: authentication using user name and password, encryption using
- MQTT-SN (protocol for sensor network) works on non-TCP/IP networks (e.g. Zigbee)
- MQTT over websocket possible (browser as MQTT client)



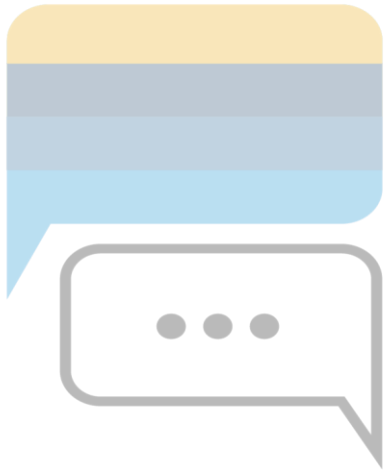
Medium.com

MQTT – Publish / Subscribe

- Multiple clients connect to a broker and subscribe to topics that they are interested in.
- Clients connect to the broker and publish messages to topics.
- Topics are treated as a hierarchy, using a slash (/) as a separator.
- Example: multiple computers may all publish their hard drive temperature information on the following topic, with their own computer and hard drive name being replaced as appropriate:
  - sensors/COMPUTER_NAME/temperature/HARDDRIVE_NAME

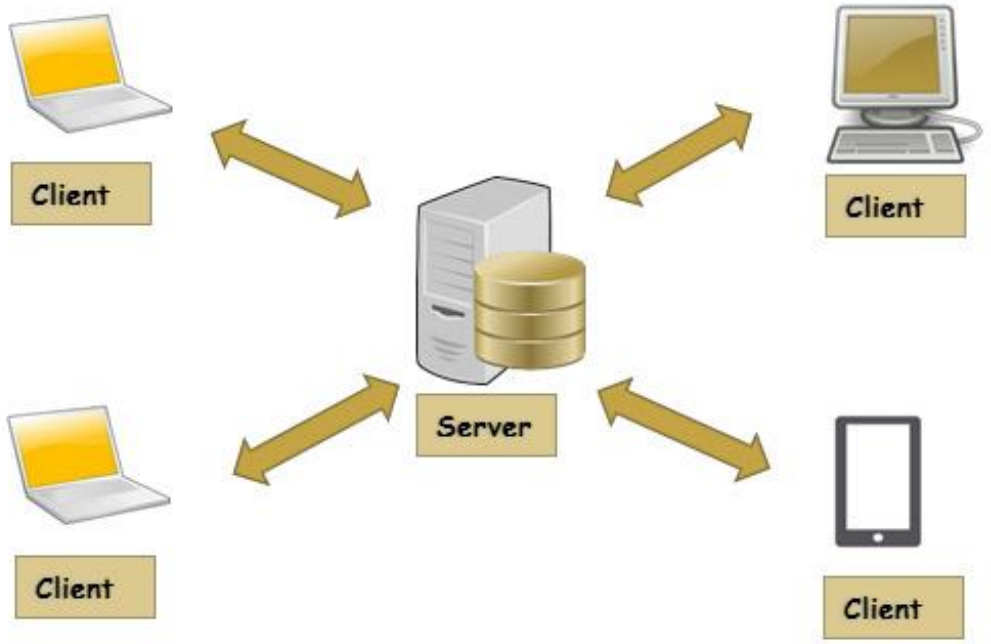
MQTT – Brokers

- HiveMQ
- ActiveMQ
- RabbitMQ
- Mosquitto
- flespi
- IBM MessageSight
- Mosca & Aedes
- MQTT Dashboard
- Eclipse IoT
- VerneMQ
- Solace
- CloudMQTT
- emqttd
- Wave
- vertx-mqtt-broker
- JoramMQ
- Moquette MQTT



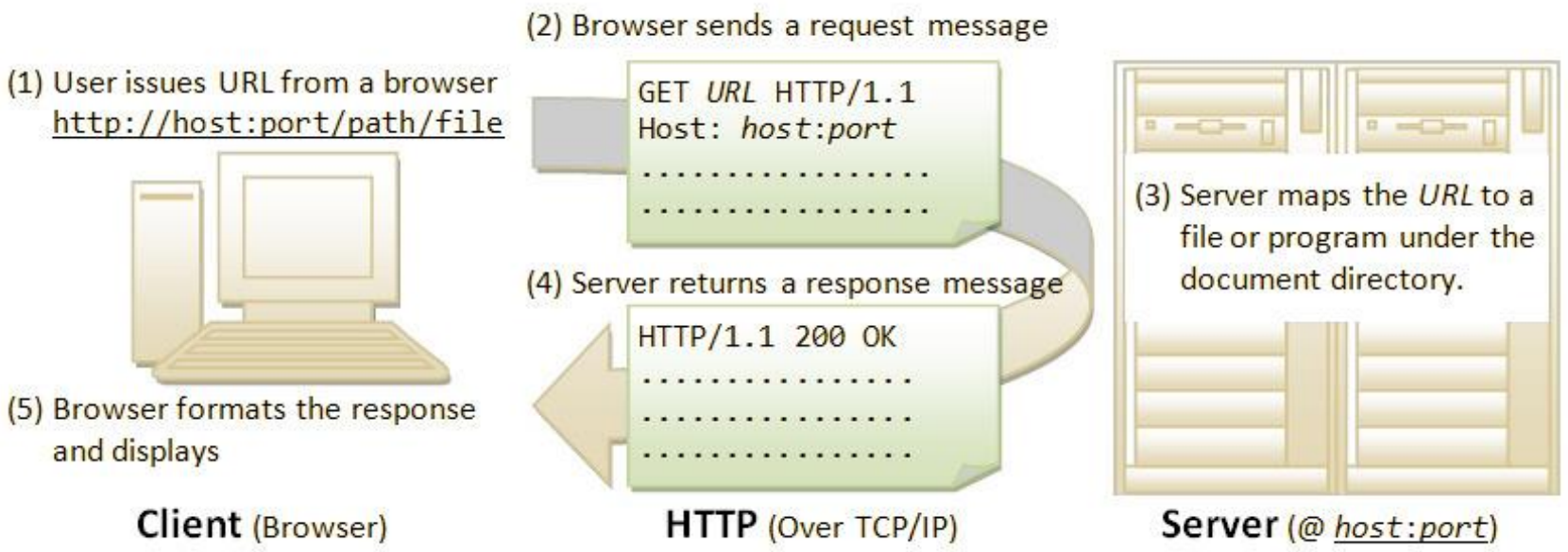
HTTP

- It is perhaps the most popular application protocol used in the Internet (or The WEB).
- HTTP is an asymmetric request-response client-server protocol.
- An HTTP client sends a request message to an HTTP server. The server, in turn, returns a response message



HTTP

- HTTP is a stateless protocol. In other words, the current request does not know what has been done in the previous requests.



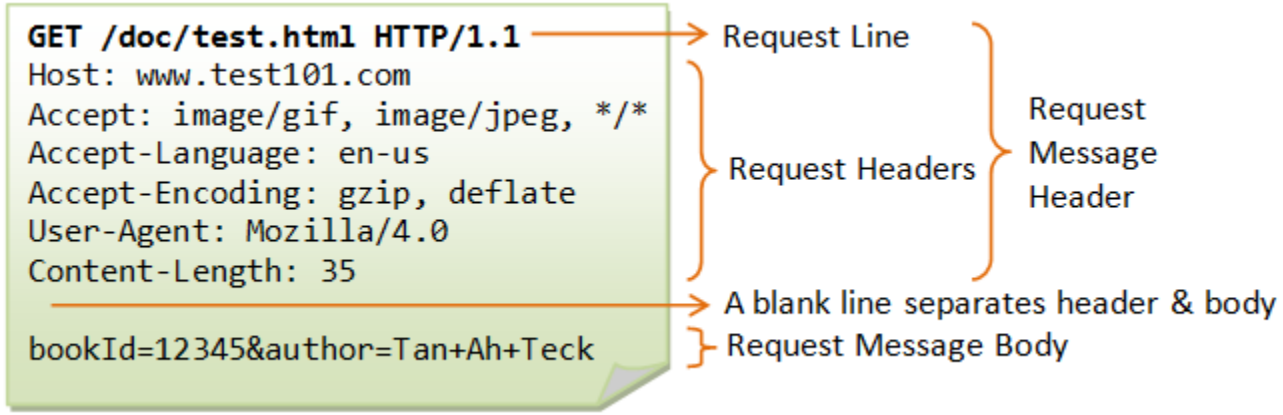
HTTP

- HTTP is a stateless protocol. In other words, the current request does not know what has been done in the previous requests.

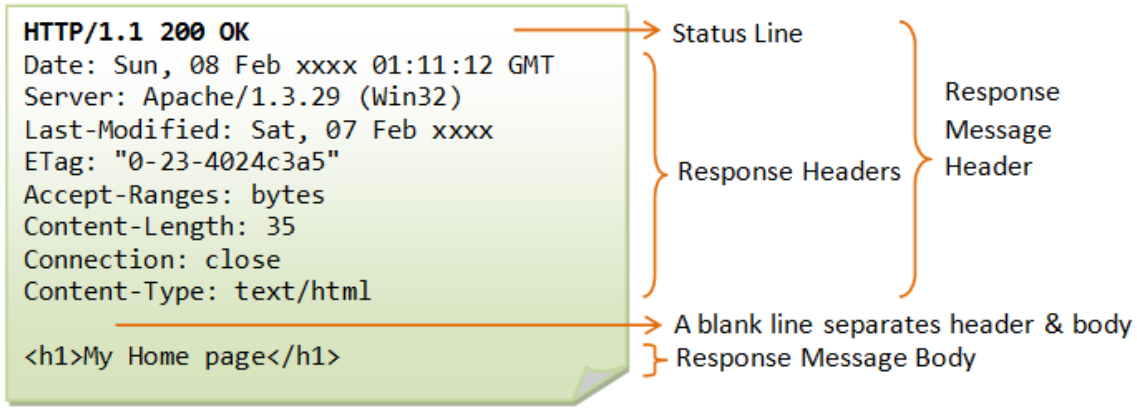
Examples of status lines:

```
HTTP/1.1 200 OK
HTTP/1.0 404 Not Found
HTTP/1.1 403 Forbidden
```

Request Headers



Response Headers



HTTP Request Methods

- **GET**: A client can use the GET request to get a web resource from the server.
- **HEAD**: A client can use the HEAD request to get the header that a GET request would have obtained. Since the header contains the last-modified date of the data, this can be used to check against the local cache copy.
- **POST**: Used to post data up to the web server.
- **PUT**: Ask the server to store the data.
- **DELETE**: Ask the server to delete the data.
- **TRACE**: Ask the server to return a diagnostic trace of the actions it takes.
- **OPTIONS**: Ask the server to return the list of request methods it supports.
- **CONNECT**: Used to tell a proxy to make a connection to another host and simply reply the content, without attempting to parse or cache it. This is often used to make SSL connection through the proxy.

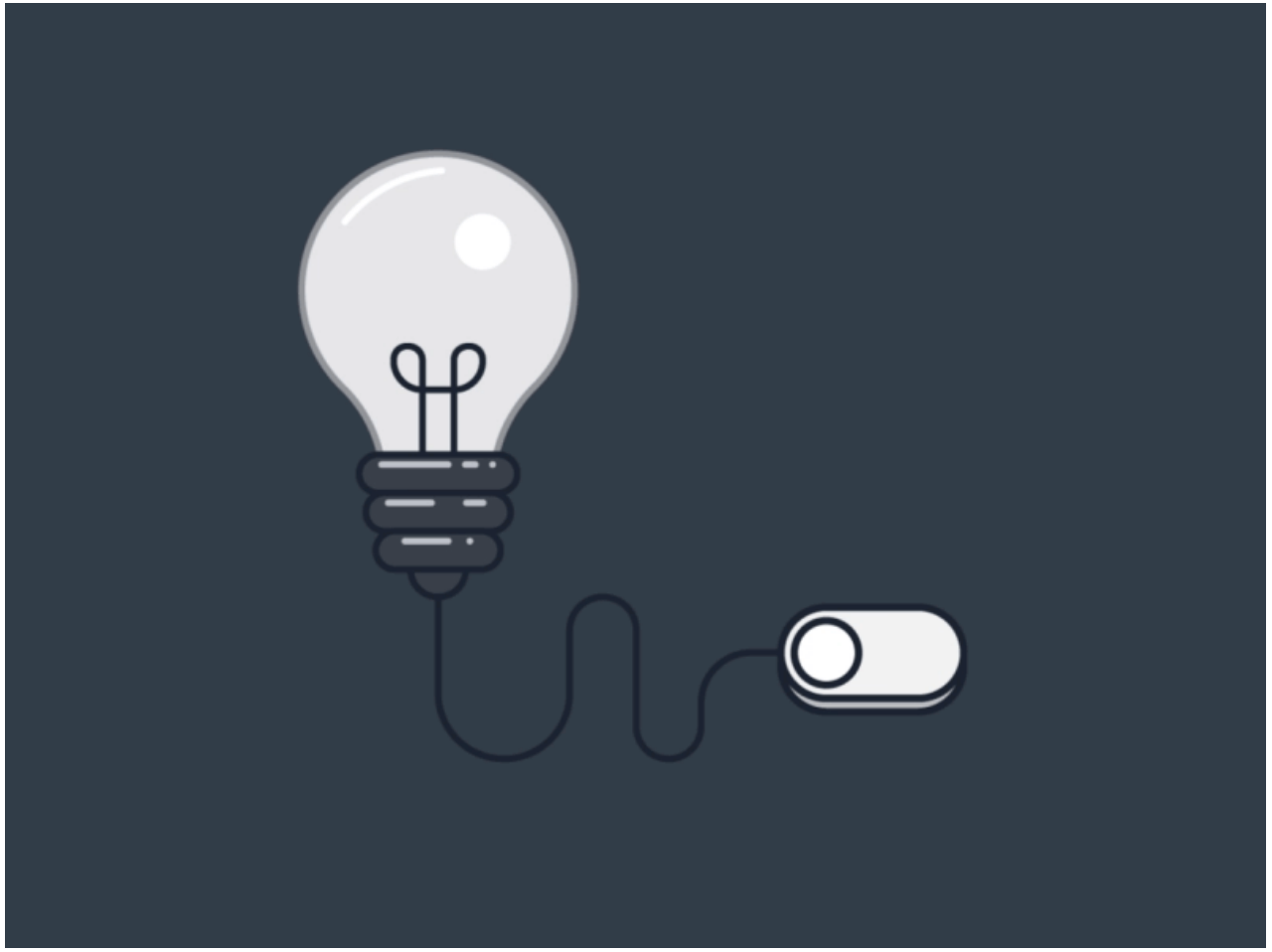
MQTT vs HTTP

FEATURES	MQTT	HTTP
Full form	Message Queue Telemetry Transport	Hyper Text Transfer Protocol
Architecture	It has publish/subscribe architecture. Here devices can publish any topics and can also subscribe for any topics for any updates.	It has request/response means Client/Server architecture.
Upper layer protocol	It runs over TCP.	It runs over TCP and UDP.
Message size	Small	Large
Message format	binary with 2Byte header	ASCII format
Data distribution	1 to 0/1/N	one to one only , more POST
Data security	Yes, It uses SSL/TLS for security	NO, hence HTTPS is used to provide data security

MQTT vs HTTP

Features	MQTT	HTTP
Complexity	Simple	Client more complex (ASCII parser)
Encryption	It encrypts payload i.e. it is payload agnostic	Data are not encrypted before transmission
When to use	If your project is to let the fridge to communicate with the thermometer to adapt the engine pump, you can use the MQTT easily	If you need to collect big data from around the world, then you can think to use HTTP

Wired Communication Protocols

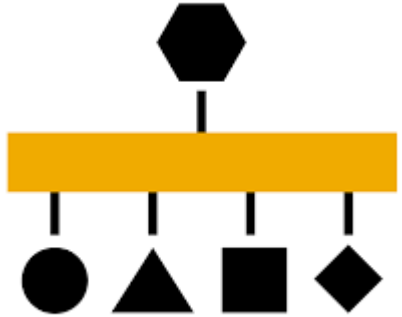


Dribbble.com

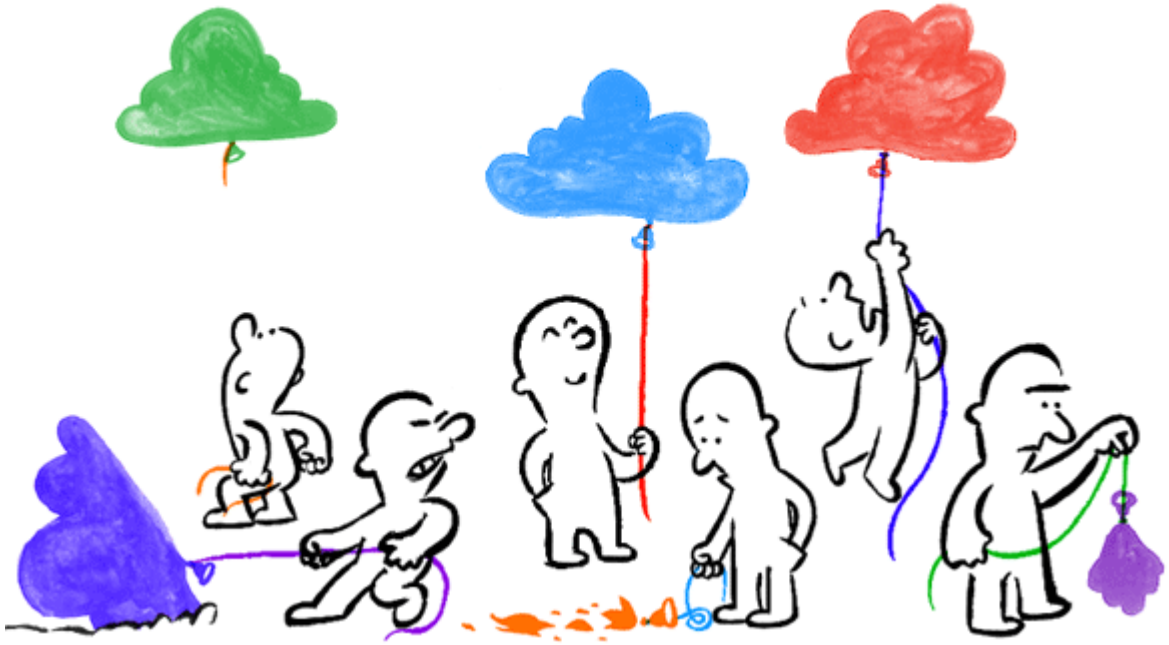
Wired Communication

- The wired communication is divided into two categories:
- Internal Communication:
  - I2C
  - SPI

- External Communication
  - Ethernet
  - RS-232
  - RS-485
  - UART
  - USART
  - USB



Cloud



Img src: https://kitchendecor.club

What is Cloud ?

The cloud is a huge, interconnected network of powerful servers that performs services for businesses and for people.

Why cloud is important in IoT?

“Most companies want a cloud solution that covers all the bases, while being flexible in the ways they can store and stream data.”

Advantages of Cloud

- Decreased costs, both upfront and infrastructure
- Pay-as-needed for storage/computing
- High system scalability and availability
- Increased lifespan of battery-powered sensors/devices
- Ability to aggregate large amounts of data
- Anything with an internet connection can become “smart”

Img src: dribble.com

Top Cloud Platforms

Azure

AWS

Google Cloud

IBM bluemix

Device management and integration

Secure gateway for devices

Cloud computing

Analytics

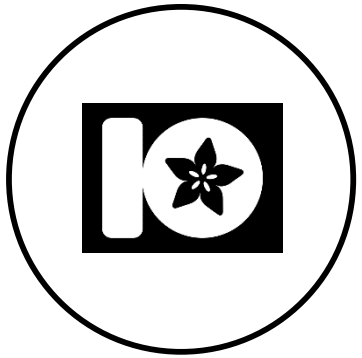
Data management and storage

Application management

Authentication and encryption

Open Source Cloud Platforms

Adafruit IO



Things board

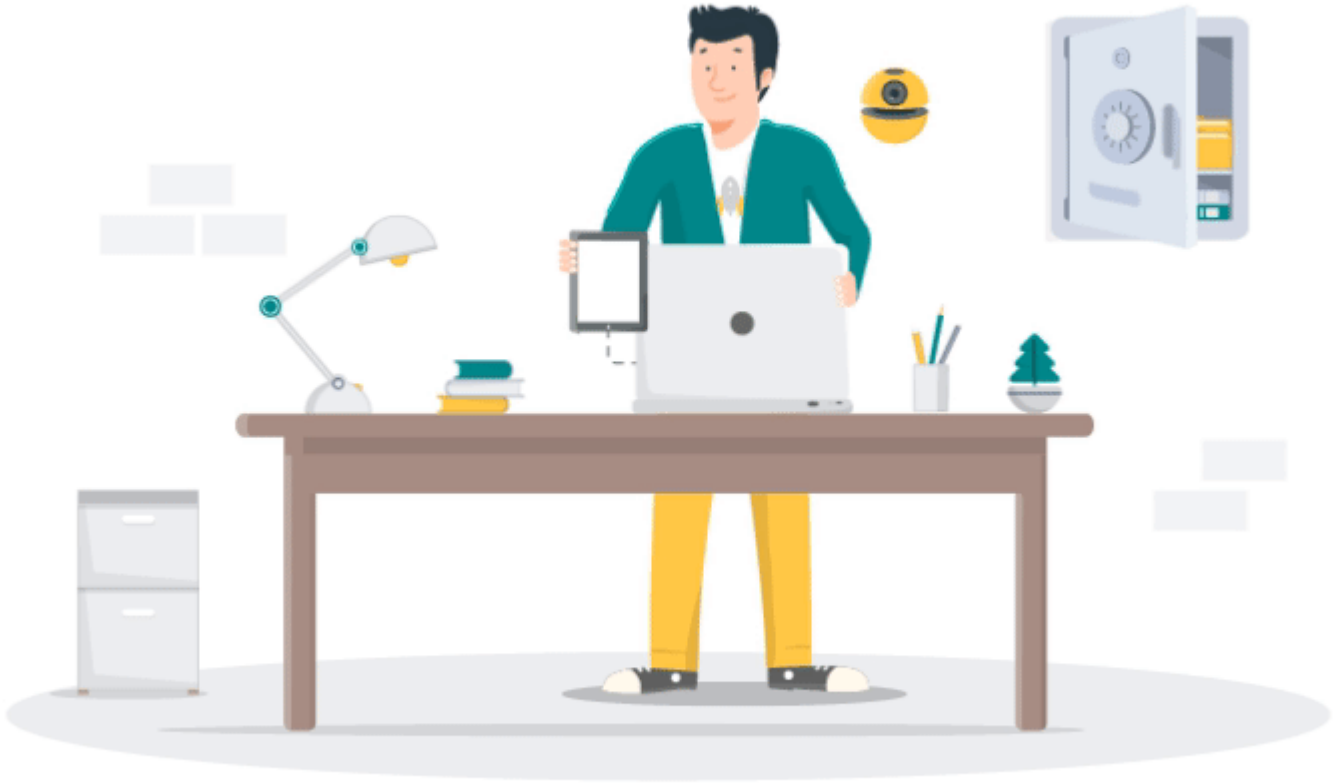
ThingSpeak

Blynk

Thinger IO

Ubidots

Security In IoT



Img src: https://dribble.com

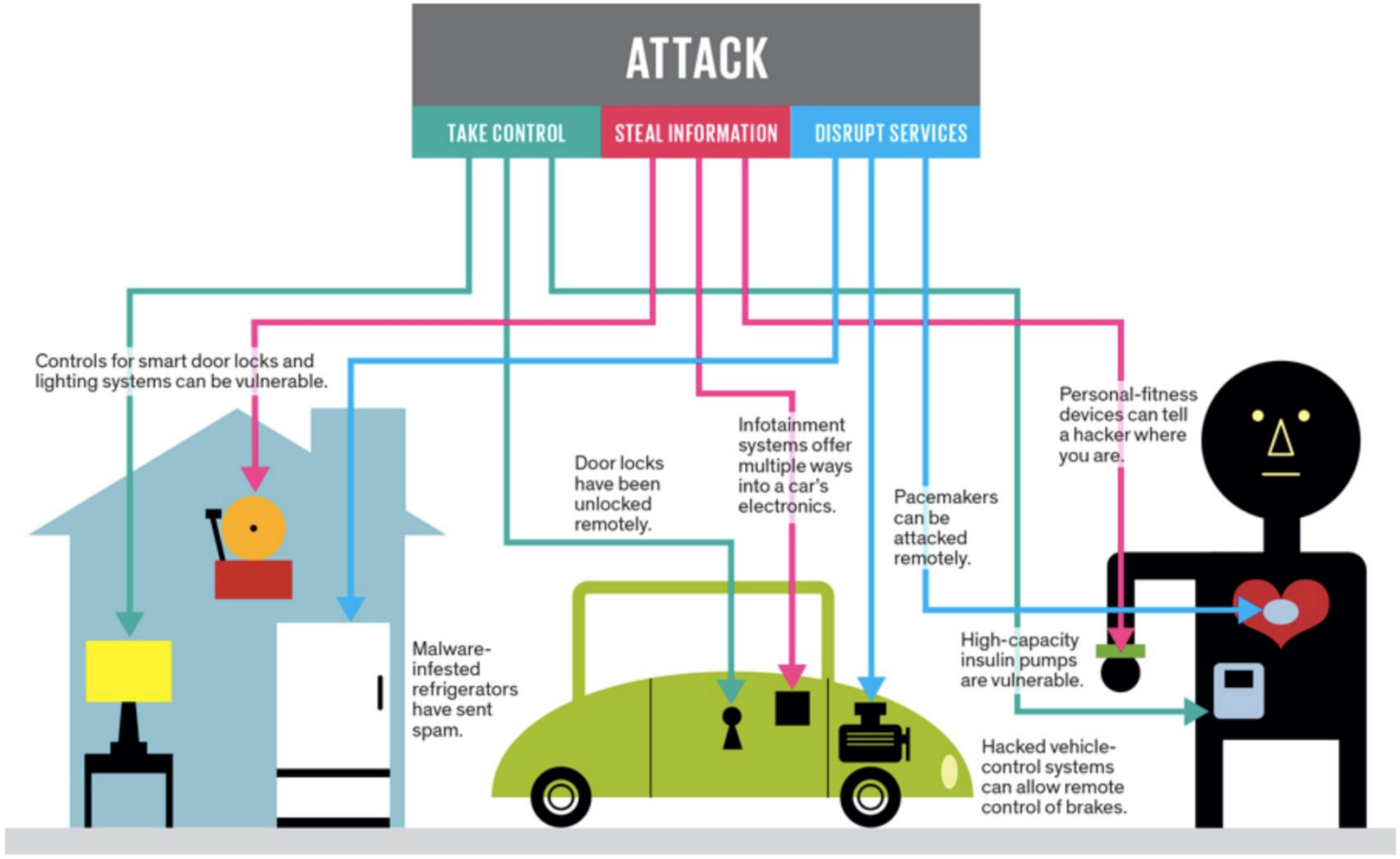
Security

- Why is security so important in IoT
- Securing the device
- Securing the network
- Managing updates

Img src: Top10VPN.com

Examples of security issues

- **Door locks**
  - Cars
  - House
- **House appliances**
  - Burn
  - Used as network bots
- **Medical devices**
  - Harm people
- **Public utilities**
  - Power grid
  - Water network



Img src: https://www.pubnub.com/wp-content/uploads/2015/04/Screen-Shot-2015-04-29-at-1.49.13-PM.png

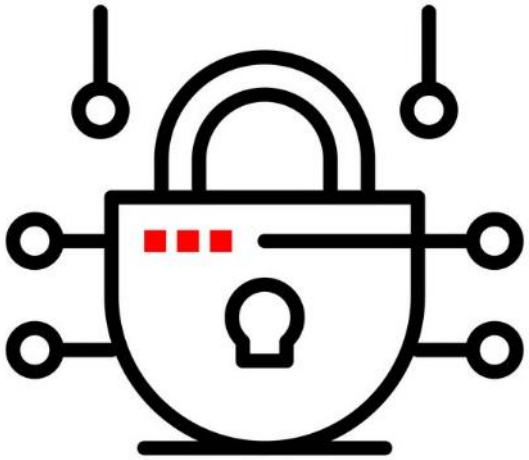
Security types

- **Security by design**
  - Theoretically proven
  - Usually open solution
  - Tested and reviewed by a large number of users
  - Trust the users

- **Security by obscurity**
  - Closed box
  - No one knows what is inside
  - If hacked, all the systems fail
  - Trust the enterprise that designed it

Securing a device

- **Local Security**
- **Network security**
- **Software**
- **Hardware**



Img src: VectorStock

Local Security

Change the default password

- **Raspberry Pi**
  - pi/raspberry
- **BeagleBone**
  - debian/temppwd

Distribute devices with a random default password

Img src: https://www.actionstep.com/ca/features/legal-data-security/

Local Security (cont.)

Disable unused services

- **SSH**
  - Login access
- **X-Server**
  - UI, unless you have a display
  - Default login
- **Avahii**
  - Device discovery (multicast)

If you don’t need it, stop it !

Disable administrator over the air

Img src: https://www.actionstep.com/ca/features/legal-data-security/

Network Security

Avoid self-written protocols

- You are the only one using it
- No one tested it
- Is it theoretically secure?
- Firewalls might stop it

Network Security

Use secure protocols

- HTTPS
  - Authenticates the server
  - Encrypted communication
- MQTT/SSL
  - Encrypted MQTT
- XMPP
  - Secure messages exchange protocol
  - Authenticates servers between each other

Img src: Best VPN Service

Network Security

Read before implementation

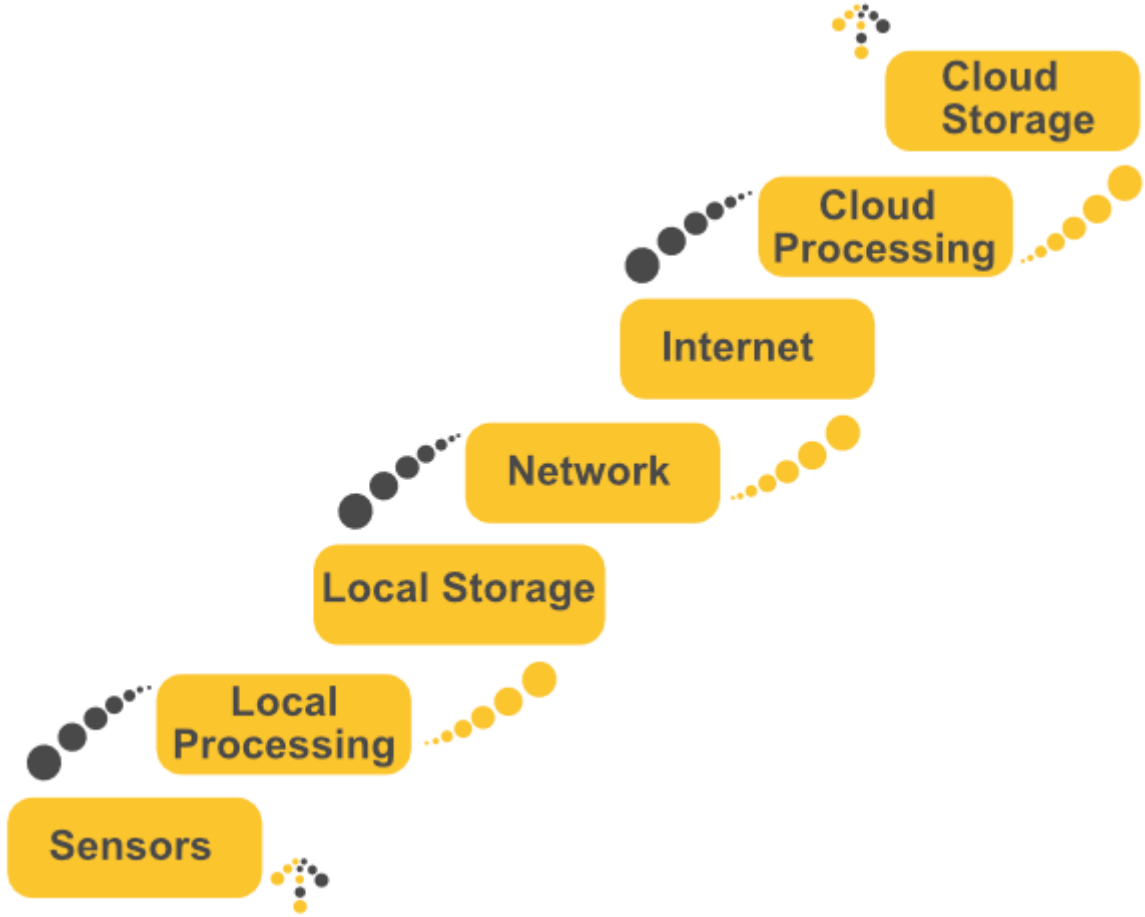
- Read about security issues in the field
- Study what experts in the field say
- Understand the security problems

Img src: UI Ex

Hardware Security

What should you use ?

- The right hardware for the right job
- Use hardware that is able to secure the network
- Follow the IoT stack



Hardware Security

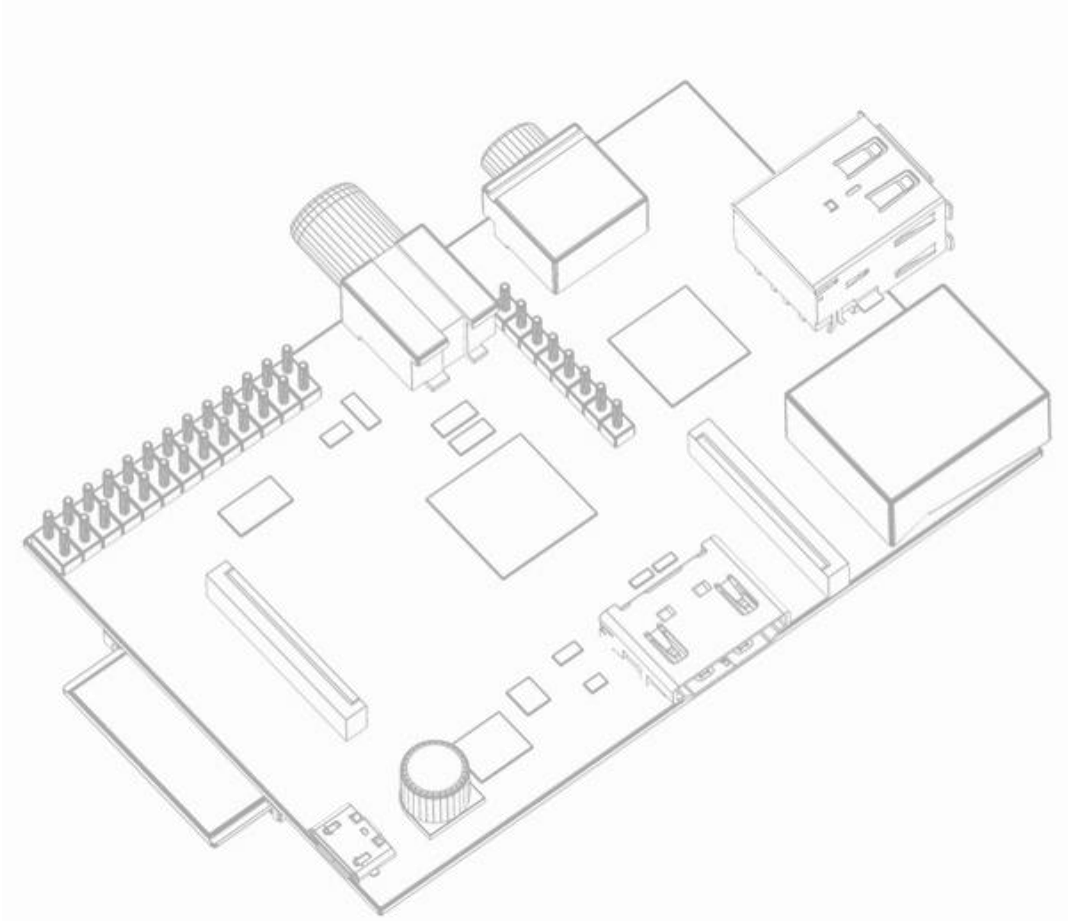
Microcontrollers and Computers

- Simple systems
- Control hardware
- Low speeds
- Small memory
- Run single software
  - RTOS

- Local network only

- Full CPUs
- High speeds
- Large memory
  - Is able to use security
- Run OS
  - Linux OS

- Local network and Internet



Software

Upstream changes

- If you change software, push it upstream
- For every software update, you have to port your software for it

Software

Use open libraries

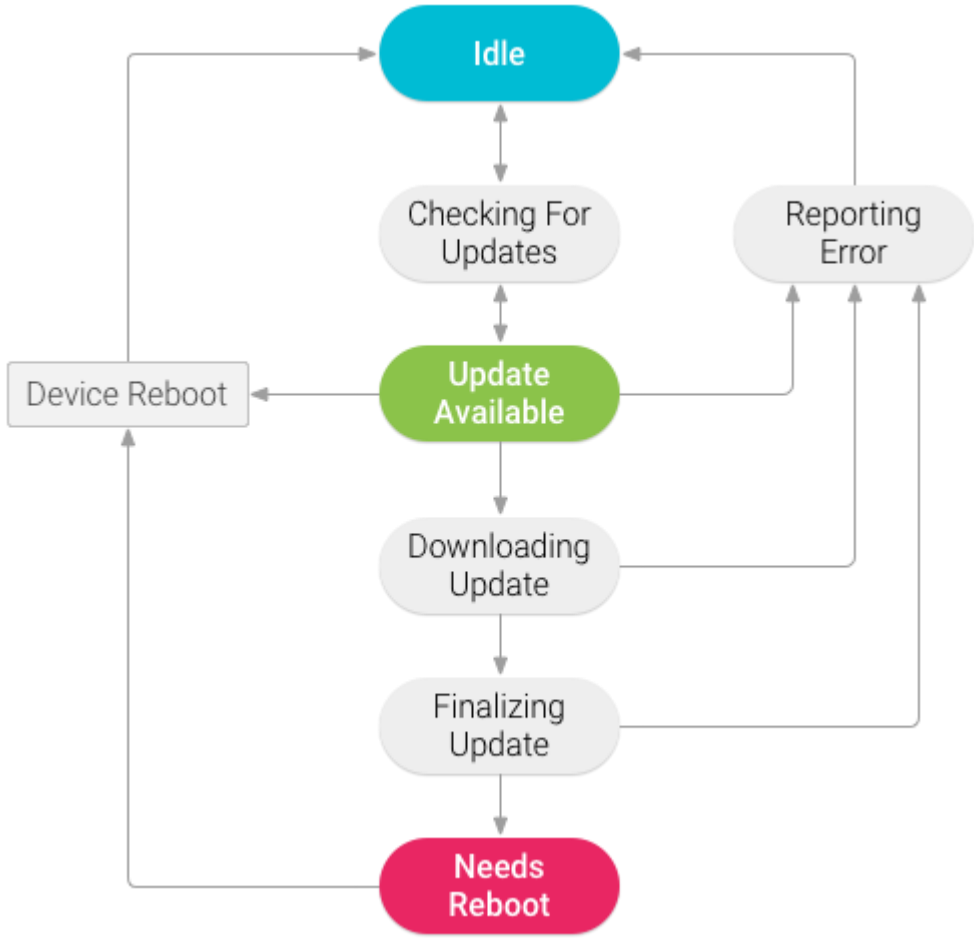
- If the protocol is used, someone wrote a library
- Use a library that is actively maintained
- Follow security updates for the library

Software

How do you update the device?

- Your software will have update
  - Features
  - Security
- Applications
  - Snap
  - Android things

androidthings



Img src: https://developer.android.com

Security

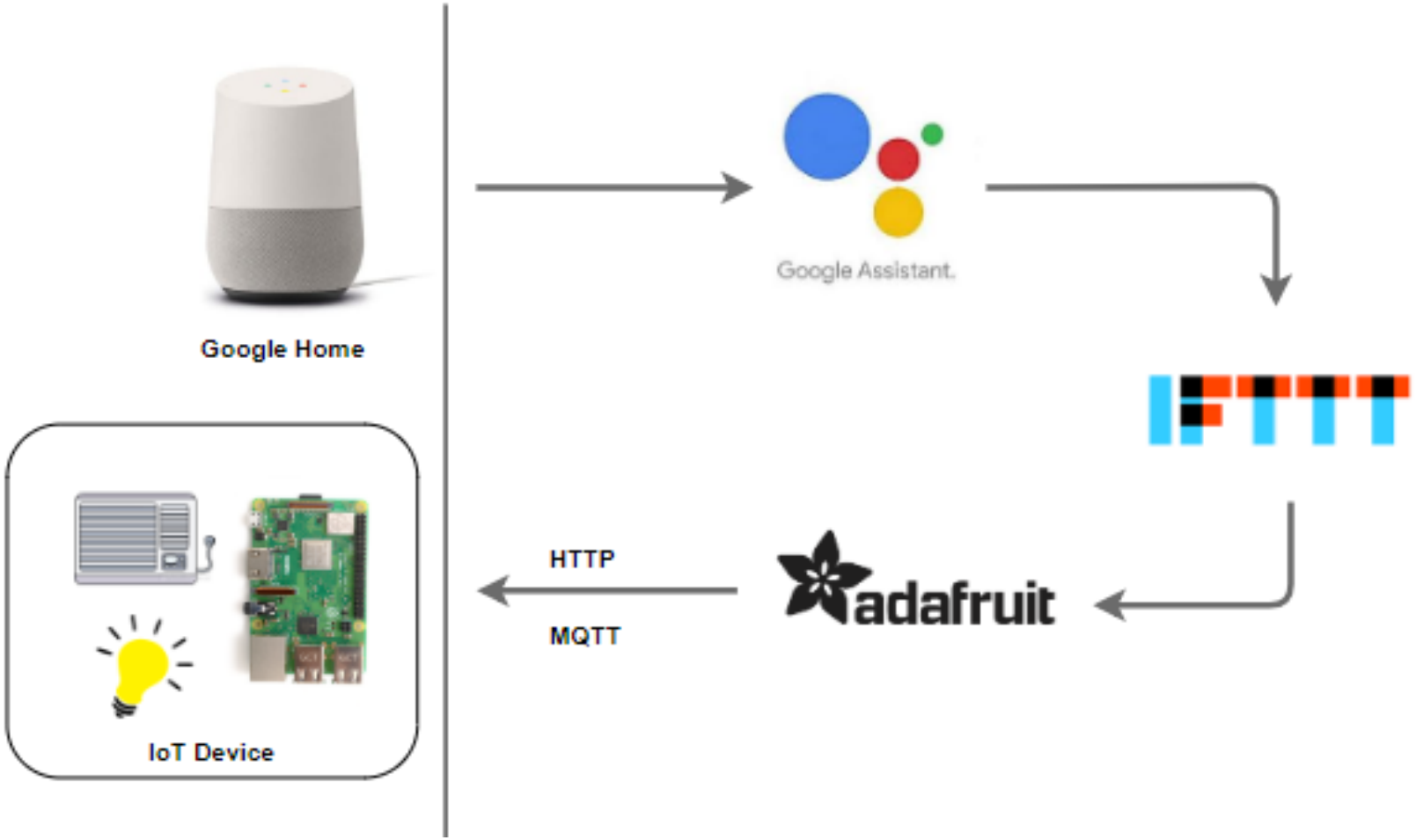
- Security by design
- Local security
- Securing the network
- Manage secure updates
- Security is important

Img src: https://giphy.com

Are You Ready For Practical Demonstration?

Img src: pinterest.com

Practical Demonstration



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